# Boston Transit Commission.

## Sixth Annual Report.

August 15, 1900.

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From

THE BOSTON TRANSIT COMMISSION,

*20 Beacon Street.*

George G. Crocker, *Chairman,*

Charles H. Dalton,
Thomas J. Gargan,

George F. Swain,
Horace G. Allen,
*Commissioners.*

Howard A. Carson,
*Chief Engineer.*

B. Leighton Beal,
*Secretary.*

SIXTH ANNUAL REPORT



OF THE

# Boston Transit Commission,

FOR THE YEAR ENDING

AUGUST 15, 1900.


BOSTON:
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1900.

# BOSTON TRANSIT COMMISSION.

20 Beacon Street,
Boston, Aug. 15, 1900.

To the City Council of the City of Boston:

In compliance with statutes of 1894, chapter 548, section 24, the report of the Boston Transit Commission for the year ending Aug. 15, 1900, is respectfully submitted:

## Subway.

At the date of the last report the subway was practically completed, only minor details of interior finish being wanting, and during the present year the expenditure upon the structure as originally planned has been less than $20,000, the greater part of this amount being final contract payments.

### *Interference with the Subway Structures by Corporations owning Structures in Streets.*

It has frequently happened that workmen employed by corporations having underground structures in the streets have not paid due regard to the necessity for preserving intact the outer coating of the subway. While the corporations concerned cheerfully promised to carefully avoid doing any injury, their workmen in many cases neglected to use due diligence, and therefore the following communication was sent to His Honor the Mayor:

Boston, Oct. 31, 1899.

To His Honor the Mayor, Josiah Quincy:

Dear Sir: I am instructed by the Commission to again call your attention to the above matter and would refer you to my letter of June 10, and also to a communication from our Chief Engineer under date of October 5.

It is not regarded as a duty of this Commission to maintain a supervision over work in the streets in the vicinity of the subway structure. The instances in which it has been brought to our attention that the subway structure has been injured have therefore been discovered only

incidentally, and it is probable that other instances have escaped our notice. From the enclosed statement it will appear that since my letter of June 10, four cases have been noted in which the subway structure was interfered with, and two of these cases have occurred since the letter of the Chief Engineer, of October 5th.

The importance of this matter is our justification for again calling it to your attention. By the lease of the subway the lessee is obliged to make repairs and keep it in good condition. (See page 10 of the printed copy.) This clause was very carefully drawn and was considered as an essential feature of a satisfactory lease. In attempting to enforce its provisions the city will be greatly embarrassed if it is proved that injury has been done to the subway structure either by the agents of the city or those acting under its authority. We therefore renew the recommendation made in the letter of the Chief Engineer, namely, that permits issued by the Superintendent of Streets be amended so as to prohibit disturbance or interference with the exterior coating of the subway, and that special inspection services be provided where permits are issued along the route of the subway. The permit might require that the cost of such inspection should be paid for by the company in whose favor the permit is issued.

Yours respectfully,

(Signed) GEORGE G. CROCKER,
*Chairman.*

### *Danger from Third Rail.*

The following is a communication to the Boston Elevated Railway Company, to which, at the date of this report, no reply has been received :

BOSTON TRANSIT COMMISSION,
20 BEACON STREET, BOSTON, June 28, 1900.

*To the Boston Elevated Railway Co.,*
WILLIAM A. BANCROFT, *President:*

DEAR SIR: Under that clause of the contract between the City of Boston and the West End Street Railway Company for the use of the subway, page 10, line 4, which requires the approval of this Commission as to the manner of use of any motive power, the Commission would like to be informed as to what method you propose to adopt to obviate or minimize the danger from the third rail in the subway.

By request of the Commission.

(Signed) GEORGE G. CROCKER,
*Chairman.*

### *Break in 30-inch Water Main.*

August 8, 1900, a break occurred in the 30-inch water main on Tremont street near the Hotel Touraine. This water main had been moved by this Commission in the construction of Section 4 of the subway. On the same day His Honor the Mayor requested a conference with the Commission in relation thereto, for the following reasons :

MAYOR'S OFFICE,
BOSTON, MASS., 8 Aug., 1900.

*To the Honorable the Boston Transit Commission :*

GENTLEMEN : Enclosed is a letter from the Superintendent of Streets. I should like to have a conference with some member of your Commission, or with your Chief Engineer, in relation thereto as soon as possible.

Respectfully,

(Signed) THOMAS N. HART,
*Mayor.*

(*Copy.*)

STREET DEPARTMENT, CITY HALL,
BOSTON, Aug. 8, 1900.

*To the Honorable the Mayor :*

The Deputy Superintendent of the Paving Division reports that in Tremont street the timber placed there by the Transit Commission when it constructed the subway, is found in large quantities, with open spaces beneath it "large enough" — to use his phraseology — "to drive a dog through."

I do not know why the Water Department should bear the expense of removing this timber, and I should not feel authorized to do it and charge it to that department, unless by your order.

I would suggest that the Transit Commission be asked to remove this timber before the new permanent pavement is placed in Tremont street between Boylston and Eliot streets, or to agree to pay this department for removing the same. Unless this is done, it seems to me that there is likelihood of a recurrence of the accident of to-day.

Respectfully,

(Signed) B. T. WHEELER,
*Superintendent of Streets.*

August 9th the Chairman and the Chief Engineer met His Honor the Mayor and representatives of the City Engineer's and Street Departments in relation to the matter, but at the date of this report there has been no further action.

## TRAVERS STREET SUBWAY FOR FOOT PASSENGERS.

The following communication from the Corporation Counsel to His Honor the Mayor is self-explanatory :

CITY OF BOSTON, LAW DEPARTMENT,
73 TREMONT STREET, BOSTON, Aug. 15, 1899.

HON. JOSIAH QUINCY, *Mayor :*

DEAR SIR : In reply to your inquiry as to "whether, in my opinion, the Boston Transit Commission can expend money for building a subway for foot travel in the line of Travers street, between Haverhill street and Canal street," I have to say that, while there is no direct authority for the expenditure of money for that purpose, the whole spirit of the act is in favor of such expenditure. Section 25 of chapter 548, Acts of 1894, establishing said Commission, authorizes it to discontinue as a public way Travers street between Canal street and Haverhill street, and the act provides that all damages occasioned by anything done by the commission shall be paid by the city from the funds placed at the disposal of said commission. It seems to me that it is no stretch

of authority given to the Commission if it discontinues Travers street and substitutes therefor a subway for the use of foot travel. There is certainly fully as much authority in the act for the construction of such a subway as there is for building the sheds on Canal and Causeway streets.

Respectfully,

(Signed) ANDREW J. BAILEY,
*Corporation Counsel.*

After conference with the officials of the Boston Elevated Railway Company a communication was received from that company dated Sept. 16, 1899, from which the following is an extract:

> This company would be pleased, however, to have an underground passageway built under Travers street if the same is authorized by the subway act. We do not consider that we have any authority ourselves to build it.

It was thereupon voted to construct such a subway and work was begun upon it on Oct. 16, 1899.

The following is an extract from a communication sent to His Honor the Mayor by the Commission on Jan. 27, 1900:

> In response to public demand, and at the request of His Honor Mayor Quincy and the Board of Estimate and Apportionment, this Commission has built a sub-passage for foot passengers under the tracks of the Elevated Railway Company at Travers street. The expense of construction is included as a part of the cost of the subway, but it seems proper that the maintenance of the passageway — namely, lighting, policing, and cleaning — should be under the control and at the expense of the city. An appropriation for that purpose will also be necessary.

The following is an extract from the reply of His Honor the Mayor under date of Jan. 31, 1900:

> The Street Department will assume charge of and maintain the sub-passage at Travers street as soon as it is laid out by the Board of Street Commissioners as a footway for public travel, or before then, if possible.

On Feb. 23, 1900, the proper authorities were notified that this subway was ready for public use. Its cost has been about $10,800.

## EAST BOSTON TUNNEL.

At the date of the last annual report the decision of the Supreme Court of the State on the application of the Citizens' Association for an injunction to restrain the Commission from proceeding with the work of construction of the tunnel to East Boston had just been received, the decision being that the tunnel if constructed must have a "physical connection" with the subway, but the Court did

not pass upon certain constitutional questions which had been raised. Plans had been adopted by the Commission in accordance with this decision, and active work was about to begin, when, on Sept. 6, 1899, notice was received of a new application for an injunction by the same association, on the ground of the unconstitutionality of the act of 1897. Thereupon preparations for active work were suspended, but office work was continued upon studies and plans so that if the Court should deny the application there might be as little delay as possible. The Commission through its counsel urged a speedy hearing of the matter, but the decision was not reached until March 28, 1900, when the Court rendered an opinion dismissing the bill. (The opinion will be found in full in appendix A.) Thereupon contract plans were prepared and on April 20, 1900, bids for the first section, Section A, were opened and the contract for the same awarded to the National Contracting Company of New York. This section is now well under way. On June 14, 1900, bids for building Section B, which includes all of the work under the harbor and as far as Fleet street on the Boston side, were opened and the contract awarded to Shailer & Schniglau Company and Dunfee & Taylor. Work on this latter contract has only just begun, the nature of the work calling for special machinery and other appliances which the contractors were obliged to get in readiness before commencing operations.

*Comparison of Two Narrow Tubes with One Wide Tube.*

The first plans of the Commission for the tunnel were made on the basis of two narrow tubes for the portion under the harbor rather than one wide tube. In December, 1899, the Chief Engineer reported to the Commission as follows :

BOSTON TRANSIT COMMISSION,
20 BEACON STREET, BOSTON, Dec. 6, 1899.

MESSRS. GEORGE G. CROCKER, CHARLES H. DALTON, THOMAS J. GARGAN, GEORGE F. SWAIN, HORACE G. ALLEN, *Boston Transit Commissioners :*

GENTLEMEN : In a letter written to the Commission last June I made an estimate of the cost of two tubes as compared with one wide tube for the portion of the East Boston tunnel under the harbor. According to the designs at that time made there appeared to be a difference in cost of about $313,000 in favor of the two narrow tubes. The designs at that time contemplated a circular form for the large tube and an additional outside tube for ventilation. Since then studies have been made for a tube having a segmental cross-section and with a space reserved for ventilation in the top. With this design it appears probable that the difference in cost can be cut down to about $120,000. I also think that we could place the large tube at a somewhat higher elevation than was contemplated last June, but even allowing for this, the inclines

would be about three hundred feet longer than for the small tubes and the platform of the station under Commercial street would be about five and one-half feet deeper than for the small tubes. Although the Commission voted at the meeting of June 15, 1899, that plans for the East Boston tunnel be proceeded with on the basis of two tubes, there appeared to be a feeling that the vote might be rescinded later, and if there is any likelihood of this I recommend that we get permission from the Secretary of War allowing the wide construction to be adopted. If the Commission should decide at some future time to proceed with the construction of the East Boston tunnel I should wish to be prepared at that time with contract plans and specifications so that the work could progress without delay. In order to be ready for such an event it would be desirable for the Commission to decide the matter above referred to and also more precisely than it has yet done as to the route to be adopted on the Boston side.

Yours respectfully,

(Signed) H. A. CARSON,
*Chief Engineer.*

At the meeting of the Commission on Dec. 7, 1899, it was voted that the Chief Engineer be requested to prepare plans for the tunnel on the basis of a single wide tube, and that application be made to the War Department for permission to construct a tunnel of that design. That permission was granted in the following terms:

WAR DEPARTMENT,
WASHINGTON, Jan. 11, 1900.

File No. 619–8.

SIR: In connection with War Department instrument of Feb. 15, 1899, granting the Boston Transit Commission permission to construct a tunnel for street railway purposes, under Boston harbor, from a point on or near Hanover street, in the City of Boston, to a point at or near Maverick square, in that part of Boston called East Boston, as shown by plan attached to said instrument, which contemplated two parallel tubes, I have the honor to acknowledge the receipt of your letter of 12th ultimo, requesting permission to substitute a single tube for the structure above referred to, if the Commission shall finally decide to employ such single tube type in the construction.

In response thereto, I transmit herewith, for retention, an instrument granting the said Boston Transit Commission permission to substitute a single tube structure for the type of structure previously authorized for said purpose, at said place, subject to the conditions set forth in the last mentioned instrument and as shown on plans attached thereto.

Very respectfully,

(Signed) G. D. MEIKLEJOHN,
*Acting Secretary of War.*

MR. GEORGE G. CROCKER, *Chairman,*
*Boston Transit Commission,*
*Boston, Mass.*

(Inclosure: 619–10.)

*Whereas*, By Section 10 of an act of Congress, approved March 3, 1899, entitled "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," it is provided that it shall not be lawful to

build or commence the building of any wharf, pier, dolphin, boom, weir, breakwater, bulkhead, jetty, or other structures in any port, roadstead, haven, harbor, canal, navigable river, or other water of the United States, outside established harbor lines, or where no harbor lines have been established, except on plans recommended by the Chief of Engineers and authorized by the Secretary of War; and it shall not be lawful to excavate or fill, or in any manner to alter or modify, the course, location, condition, or capacity of, any port, roadstead, haven, harbor, canal, lake, harbor of refuge, or inclosure within the limits of any breakwater, or of the channel of any navigable water of the United States, unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War prior to beginning the same;

*And Whereas*, By an instrument dated Feb. 15, 1899, the Secretary of War granted unto the Boston Transit Commission permission to construct a tunnel, for street railway purposes, under Boston Harbor, from a point on or near Hanover street, in the city of Boston, to a point at or near Maverick square, in that part of Boston called East Boston, Mass., as shown by a plan attached to said instrument which contemplated two parallel tubes:

*And Whereas*, Said Boston Transit Commission now requests permission to substitute a single-tube structure, as shown on the plans hereto attached, for the structure previously authorized, if said Commission should finally decide to employ such single-tube type of structure; which plans have been recommended by the Chief of Engineers, subject to the conditions hereinafter set forth;

*Now, Therefore*, This is to certify that the Secretary of War hereby gives unto said Boston Transit Commission permission to substitute a single-tube structure, as shown on said plans, for the type of structure previously authorized for said purpose, at said place, should said Commission finally decide to employ such single-tube type of structure, subject to the following conditions:

1. That in case a future increase in channel depth necessitates a lowering of the structure herein authorized, the same shall be promptly done by said Commission without expense to the United States.

2. That the work herein permitted to be done shall be subject to the supervision and approval of the engineer officer of the United States Army in charge of the locality.

*Witness* my hand this eleventh day of January, 1900.

(Signed) G. D. Meiklejohn,
*Acting Secretary of War.*

Seal.

## *Width of the Tunnel.*

On the day on which bids for the construction of Section B were opened the following communication was received from the Boston Elevated Railway Company:

Boston Elevated Railway Company,
Boston, Mass., June 14, 1900.

*To the Honorable Board of Transit Commissioners, 20 Beacon street, Boston, Mass.:*

Dear Sirs: A letter of Mr. C. S. Sergeant, Vice-President of this Company, dated June 9, current, was submitted by me to the Executive

Committee of the Board of Directors. The Committee instructed me to supply you with a copy.

The view taken by Mr. Sergeant is adopted as the view of this Company, and we earnestly hope that it is not too late to cause an enlargement of the proposed tunnel, so that provisions may be made for such conditions as are suggested by Mr. Sergeant.

I enclose herewith blue print to which reference is made.

I am

Very respectfully, etc.,

(Signed) WM. A. BANCROFT,

*President.*

EAST BOSTON TUNNEL.

BOSTON, MASS., June 9, 1900.

GEN. WILLIAM A. BANCROFT, *President:*

DEAR SIR: Mr. Kimball and myself had a while ago an interview with Mr. Carson about the dimensions of the East Boston tunnel, which, as we understood it, were inadequate. I have since procured from Mr. Carson blue print of the dimensions, showing various different sections of the tunnel, and have had Mr. Plimpton prepare drawing showing, within a typical section, two elevated cars with the third rail system.

I do not consider this proposed tunnel of sufficient size for safety of operation. My objection to the size in regard to clearance of cars is based upon what I believe to be as necessary as a track, namely, a safe walk beside the track on which passengers may escape in the event of accident or fire, contingencies which are liable to occur, and should be provided against. There is also no provision — nor apparently adequate room for provision — for wires, which I think should be a part of the tunnel system. At first glance it would seem that they might be placed above the tie rods in the arch of the roof, but this place is not continuous, and the tie rods will be presumably so near together as to make it almost impossible to string wires in the place if it were continuous.

I do not think, either, that the section of the bottom of the tunnel provides adequately for track construction. There would not be ballast enough about the ends of the ties to properly hold a track, a difficulty which we experience in some degree in the present subway. Mr. Plimpton's opinion on this point is herewith submitted.

As the tunnel is to be built for railway purposes, it would seem necessary that it should be so designed as to be practical for the construction and safe operation of a railway, and if any action on our part can remedy these defects, it should be taken at once, because some contracts are already let, and construction work is going on.

Very respectfully,

(Signed) C. S. SERGEANT,

*Vice-President.*

To the foregoing, after consultation with the Chief Engineer, the following reply was made:

BOSTON TRANSIT COMMISSION,
20 BEACON STREET, BOSTON, June 21, 1900.

GEN. WILLIAM A. BANCROFT, *President Boston Elevated Railway Company:*

DEAR SIR: Your communication under date of June 14, relating to the size of the tunnel to East Boston, has been received and considered by this Commission.

The cross-section of the tunnel as proposed and as made public about a year and a half ago is practically in all its dimensions as large and in some dimensions larger than the cross-section of the two-track subway under Tremont street, as shown on the sketch enclosed, in which the solid white line shows the present subway and the broken line the proposed tunnel.

It appears that there is room enough at the side of the cars in case of a blockade for a safe walk for people in single file; that there is plenty of room for all wires which can be needed in connection with the operation of the tunnel, and that the ties can be safely laid.

In view of the foregoing and also of the fact that a part of the tunnel is under actual construction, and a large proportion of the remainder is under contract, we do not consider that we would be justified in enlarging the tunnel at an additional cost of from $200,000 to $300,000.

Please give the matter further consideration and if you still adhere to the tenor of your letter, will you meet the Commission on Thursday, June 28, at such time between 10.30 A.M. and 1 P.M. as you may appoint, so that we may more fully understand each others' views?

Yours very truly,

(Signed) GEORGE G. CROCKER,
*Chairman.*

Blue print enclosed B.T.C. plan 5093.

The conference above suggested was held June 28, after which the following letter was sent to the Boston Elevated Railway Company by the Chief Engineer of the Commission:

BOSTON TRANSIT COMMISSION,
20 BEACON STREET, BOSTON, July 26, 1900.

GEN. WILLIAM A. BANCROFT, *President Boston Elevated Railway Co., 101 Milk Street, Boston, Mass.:*

DEAR SIR: I am instructed by the Commission to write to you in regard to the principal point raised in your conversation with the Commission June 28, 1900. You feared that the distance x–y on sketch 5,115 (blue print enclosed herewith) would not be enough in the cross-section of the East Boston tunnel as shown. In order to get information based on recent experience a letter was sent to seven important steam railroads of standard gauge known to have tunnels. They were asked as to what were the usual and minimum distances at x–y on their roads in tunnels or arched bridges and at what speed their trains ran in passing the same. As the information sent was presumably confidential the names of the roads are not given. The following is a synopsis of the information received — three not giving the information asked for:

*1st R. R.* If the track is straight would be willing to risk a minimum clearance of 6 inches. We have some points in our tunnel where the clearance is not more than 6 inches and I have not heard any complaint of cars striking. Of course 12 inches would be more desirable.

*2d R. R.* The usual clearance allowed is about 6 inches and the speed of trains is not limited. Have allowed cars to pass through where there was a clearance of but 4 inches and 4½ inches with the understanding that trains run very carefully, but do not consider this safe practice. If track was carefully watched should say clearance of 5 inches was a safe minimum under ordinary conditions.

*3d R. R.* Our limit line in the . . . tunnel is 4 inches inside of

(The distance "x–y," referred to in the foregoing communication, is that between the "gutter-molding," so-called, of the car and the side of the tunnel.)

arch lining at the point x–y on print. This is much closer than at any other place on road, but have never heard of any trouble on account of it. Passenger trains scheduled about 36 miles per hour in tunnel and frequently run faster.

*4th R. R.* The practice on our road is to assume 4½ inches as a safe allowance for the swinging and swaying of cars. Closest clearance we have ordinarily is about 2¾ inches, in the . . . tunnel, no limitation being placed on the speed of train. Gives instance of an actual clearance of about 1 inch, but considers it rather risky, for occasionally car scrapes sides of tunnel.

Considering that there is at x–y a clearance for the cars which you expect to run of 17 inches and that for the larger cars which you may possibly run in the future a clearance of 10 inches, and taking into account all the other circumstances mentioned in Chairman Crocker's letter of June 21, the Commission does not see its way clear to make the tunnel larger.

Yours respectfully,

(Signed) H. A. CARSON,
*Chief Engineer.*

## *Communications to the City Government.*

The following correspondence has passed between this Commission and the Executive Department of the City:

MAYOR'S OFFICE, CITY HALL,
BOSTON, Sept. 20, 1899.

*To the Boston Transit Commission:*

GENTLEMEN: I have been requested by the Board of Aldermen to enquire of your Commission if work on the East Boston tunnel is proceeding as vigorously as possible, and to transmit your reply to the Board. I should be pleased to transmit to the Board of Aldermen any report which you might send to me in regard to the matter.

Yours respectfully,

(Signed) JOSIAH QUINCY,
*Mayor.*

BOSTON TRANSIT COMMISSION,
20 BEACON STREET, BOSTON, Oct. 4, 1899.

HON. JOSIAH QUINCY, *Mayor:*

DEAR SIR: The Boston Transit Commission respectfully makes reply to your request for information for the Board of Aldermen as to the progress of work upon East Boston tunnel.

As soon as the Supreme Court rendered its opinion of July 3, the Commission rescinded its votes looking to a surface connection between the subway and the proposed tunnel to East Boston, and August 3 voted to proceed with the construction of the tunnel as required by Chap. 500, Statutes of 1897, and as interpreted by the Supreme Judicial Court in Browne *et al.* versus Turner *et al.*

The engineering force thereupon recommenced making plans, studies, and estimates of cost, a material change from former plans in the method of construction being made necessary by the great increase of late in the cost of steel and cast iron. An immediate investigation was instituted to learn to what extent concrete masonry can be safely substituted for metal.

Additional borings have been made, some requiring the use of the diamond drill, and a small section of tunnel has been constructed in East Boston to serve for a practical test of the strength of the method of construction now proposed.

Early in September notice was received of an application by ten citizens again asking for an injunction to restrain the Commission from building the tunnel. In this proceeding the constitutionality of the act will undoubtedly be passed upon by the Court. By the advice of counsel active work on the tunnel has again been suspended pending the decision of the Court. The counsel of the Commission has been instructed to hasten the matter to an early hearing.

Yours respectfully,

(Signed) GEORGE G. CROCKER,
*Chairman.*

MAYOR'S OFFICE, CITY HALL,
BOSTON, Oct. 24, 1899.

*To the Boston Transit Commission:*

GENTLEMEN: A report has been brought to my attention that the Chief Engineer of the Board, Mr. Howard A. Carson, has revised his estimates of the cost of the East Boston tunnel so as to permit the construction, within the appropriation available for the purpose, of such a tunnel as the Supreme Judicial Court in the case of Browne *v.* Turner decided must be built, that is to say, a tunnel connecting physically with the subway.

Will you kindly inform me whether this is so or not? and in case the report be true, I should like an opportunity to see any plans that may have been prepared showing in what manner the Commission proposes to effect the junction between the tunnel and the subway, together with Mr. Carson's revised estimates of cost and the reasons for reducing his figures.

Very truly yours,

(Signed) JOSIAH QUINCY,
*Mayor.*

BOSTON TRANSIT COMMISSION,
20 BEACON STREET, BOSTON, Oct. 28, 1899.

HON. JOSIAH QUINCY, *Mayor:*

DEAR SIR: The Boston Transit Commission has the honor to acknowledge the receipt of your letter of Oct. 24 inquiring whether their Chief Engineer, Mr. Carson, has revised his original estimate of the cost of a tunnel to East Boston, and making also other inquiries.

In reply the Commission states that the recent considerable advance in the prices of cast iron and steel led Mr. Carson to consider whether a mode of constructing the tunnel differing from that upon which his previous estimates had been based could be adopted.

Investigation, supplemented by the construction and test of an experimental section, has led him to the conclusion that by a larger use of cement and a less use of steel a safe and practicable tunnel can be built, making an underground connection with the subway, at a cost slightly less than $2,700,000.

The present subway has proved to cost less than was anticipated a few months since, and consequently the amount available for the tunnel is believed to be sufficient to build such a tunnel as the recent decision of the Supreme Court decides must be built.

The new estimates and plans of the tunnel are necessarily provisional

and subject to revision and alteration. The Commission will be glad to exhibit and explain them to you when you can conveniently call.

Very truly,

(Signed) GEORGE G. CROCKER,
*Chairman.*

### *Deepening of the Shore Ends.*

In accordance with suggestions from the War Department as to the possibility of further deepening of the channel, the depth of the shore ends of the tunnel has been lowered from a little over thirty-five feet to forty-five feet.

### ALTERATIONS.

Slight alterations have been made in the subway at the request of the Boston Elevated Railway Company, such as chipping off small portions of the sidewalls (not to a sufficient extent to impair the strength of the structure) to allow sufficient clearance for the cars to be used on the elevated trains. The railway company, under Stat. 1897, Chap. 500, has formally requested the making of the alterations at Pleasant street for connection with the elevated tracks under that street. By the plan proposed by the railway company and approved by the Board of Railroad Commissioners all connection with the subway by surface cars at that point will be cut off, a fact upon which emphasis was laid in the fourth annual report of this Commission. The Commission made studies by which the Tremont-street surface connections could be retained in such a manner as not to interfere, in its opinion, with the elevated service, and on Feb. 8, 1900, a conference was held with His Honor the Mayor and the officials of the railway company to urge the adoption of some such plan. The operating company, however, after due consideration decided to adhere to its original scheme, and the plans for the change are nearly completed and proposals about to be invited for the work. It is expected that the changes will be completed about Jan. 1, 1901.

The property taken at the corner of Court and Brattle streets for the entrance to the easterly platform was advertised for sale on Sept. 21, 1899, but no satisfactory offers were received, and the property has been placed in the hands of Messrs. A. S. Porter and J. G. Freeman for disposal. Until such sale is effected the Boston Elevated Railway Company has been given the privilege of renting it.

The cost of the alterations made by the Commission at the request of the Boston Elevated Railway Company, in accordance with requirements of Stat. 1897, Chap. 500, is at this date $201,276.42.

## Charlestown Bridge.

The new bridge to Charlestown was formally opened on Monday, Nov. 27, 1899, and has been in continuous use since that date with the exception of a few days during which it was closed for the purpose of enlarging some of the machinery which operates the hydraulic jacks at each end of the draw. The usefulness of the bridge has been well evidenced by the amount of traffic which daily passes over it, this structure serving the greater part of the traffic which formerly passed over Warren bridge except such heavy teams as are prohibited by the grades from making use of it. A full description of working time and delays to traffic will be found in the report of the Chief Engineer.

Daily reports were received from Dec. 13, 1899, to May 7, 1900, by the Commission of the number of openings of the draw and the duration of each from the closing of the gates to the resumption of traffic. In that period there were 1228 openings. From Jan. 11, 1900, the daily reports also included the number of vessels passing under the draw and not requiring openings. The total number so passing was 578, while the number of openings in the same period was 986.

Much progress has been made in the settlement of grade damages caused by the construction of the approaches, and all of the real estate taken for the bridge has been paid for with the exception of three estates in City square.

The old Charles river bridge has been removed between the lines established by the Harbor and Land Commissioners and the remaining portions will be turned over to the city for approaches for public landings as required by Chapter 548, Acts of 1894.

An exhaustive statement concerning the planning, construction, and operation of the bridge will be found in the report of the Chief Engineer for Charlestown Bridge. The cost of the bridge to date has been $1,453,284.04.

The ordinary cost of maintenance of the bridge was assumed by the Street Department at the close of business, Jan. 31, 1900, as shown by the following extracts from correspondence :

Boston Transit Commission,
20 Beacon Street, Boston, Jan. 27, 1900.

Hon. Thomas N. Hart, *Mayor :*

Dear Sir : The cost of the maintenance of the new bridge to Charlestown, including lighting, extra crew for draw-tenders, etc., has thus far been paid by this Commission. The machinery having now been

duly tested, it seems that the first of February would be a proper time for the assumption of this expense directly by the city, and your attention is called to this matter in order that suitable provision for the maintenance of the bridge may be made in the estimates for the coming year.

. . . . . . . . . . . . .

Respectfully,

(Signed) BOSTON TRANSIT COMMISSION,
By GEORGE G. CROCKER,
*Chairman.*

MAYOR'S OFFICE,
CITY HALL, BOSTON, 31 Jan., 1900.

*To the Boston Transit Commission:*

After the close of business to-day, the Street Department will take charge of and maintain the new bridge to Charlestown.

. . . . . . . . . . . . .

Respectfully,

(Signed) THOMAS N. HART,
*Mayor.*

In September the following license was granted by the Board of Harbor and Land Commissioners for the construction of a pile wharf on the westerly side of the Charlestown approach to render more available for use certain of the storage spaces built under that approach to the bridge.

COMMONWEALTH OF MASSACHUSETTS.

No. 2285.

*Whereas*, The Boston Transit Commission, of Boston, in the County of Suffolk, and Commonwealth aforesaid, has applied to the Board of Harbor and Land Commissioners for license to build a pile wharf on Charles river on the westerly side of the Charlestown approach to Charlestown bridge, in the city of Boston, and has submitted plans of the same; and whereas due notice of said application, and of the time and place fixed for a hearing thereon, has been given, as required by law, to the Mayor and Aldermen of the city of Boston:

*Now*, said Board, having heard all parties desiring to be heard and having fully considered said application, hereby, subject to the approval of the Governor and Council, authorizes and licenses the said Boston Transit Commission, subject to the provisions of the nineteenth chapter of the Public Statutes, and of all laws which are or may be in force applicable thereto, to build a pile wharf on Charles river on the westerly side of the Charlestown approach to the Charlestown bridge, in the city of Boston, in conformity with the accompanying plan No. 2285 within lines described as follows: Beginning at a point marked E on said plan, at the southwesterly corner of the abutment of the Charlestown bridge, and running southwesterly in the prolongation of the line of said abutment 31 feet to a point marked F; thence running northwesterly, at right angles with said line E–F, 118.33 feet, to a point marked G in the sea-wall shown on said plan; thence running northeasterly in said sea-wall 31 feet, more or less, to a point marked H in the present structure shown on said plan; thence running southeasterly 120.5 feet to E, the point of beginning.

The plan of said work is on file in the office of said Board, numbered 2285, and a duplicate of said plan accompanies this license, and is to be referred to as a part hereof.

Nothing in this license shall be so construed as to impair the legal rights of any person.

This license shall be void unless the same and the accompanying plan are recorded, within one year from the date hereof, in the Registry of Deeds for the County of Suffolk.

*In witness whereof*, said Board of Harbor and Land Commissioners have hereunto set their hands this nineteenth day of September in the year eighteen hundred and ninety-nine.

(Signed) WOODWARD EMERY, CLINTON WHITE, CHAS. C. DOTEN, } *Harbor and Land Commissioners.*

COMMONWEALTH OF MASSACHUSETTS.

BOSTON, Sept. 20, 1899.

Approved by the Governor and Council.

(Signed) E. F. HAMLIN,
*Executive Secretary.*

## PARIS EXPOSITION.

At the request of the Board of Paris Exposition Managers, the Commission made a small exhibit at that exposition of its work on the subway, consisting of photographs and plans and cross-sections of the work. For this it was awarded the diploma of a Grand Prix.

## PAYMENTS TO SINKING FUND.

The following premiums on bond issues and receipts from all sources have been paid into the Rapid Transit Sinking Fund during the year, not including income from investments or interest on deposits :

ON SUBWAY (INCLUDING ALTERATIONS) ACCOUNT.

| | | |
|---|---|---|
| **1900.** | | |
| July 27. | Premium on $50,000 3 per cent. bonds . . | $4,408 50 |

ON CHARLESTOWN BRIDGE ACCOUNT.

| | | |
|---|---|---|
| **1900.** | | |
| Jan. 4. | Rental of storage space under Charlestown bridge . . . . . . . . . . | $75 00 |
| Jan. 9. | Premium on $200,000 3½ per cent. bonds . . | 15,394 00 |
| July 27. | Premium on $200,000 3 per cent. bonds . . | 17,634 00 |
| | | $33,103 00 |

Condition of the Sinking Fund to date, including interest on investments :

### SUBWAY (INCLUDING ALTERATIONS).

*(Debt, $4,750,000 outside debt limit.)*

| | |
|---|---|
| Amount of fund, Aug. 15, 1899 | $292,329 98 |
| Interest on bank deposits, Aug. 15, 1899, to date | 1,078 49 |
| Interest on investments, Aug. 15, 1899, to date | 10,845 00 |
| Revenue received, Aug. 15, 1899, to date | 83,968 28 |
| Premium on loan | 4,408 50 |
| | $392,630 25 |

### CHARLESTOWN BRIDGE, NO. 1.

*(Debt, $750,000 inside debt limit.)*

| | |
|---|---|
| Amount of fund, Aug. 15, 1899 | $39,660 21 |
| Interest on bank deposits, Aug. 15, 1899, to date | 397 02 |
| Interest on investments, Aug. 15, 1899, to date | 987 00 |
| Revenue received, Aug. 15, 1899, to date | 75 00 |
| Requirement for debt | 8,841 00 |
| | $49,960 23 |

### CHARLESTOWN BRIDGE, NO. 2.

*(Debt, $800,000 outside debt limit.)*

| | |
|---|---|
| Amount of fund, Aug. 15, 1899 | $29,577 08 |
| Interest on bank deposits, Aug. 15, 1899, to date | 282 43 |
| Interest on investments, Aug. 15, 1899, to date | 700 00 |
| Revenue received, Aug. 15, 1899, to date | 2,061 00 |
| Premium on loans | 33,028 00 |
| | $65,648 51 |

## AMOUNTS PAID FOR RENTAL OF THE SUBWAY.

The following sums have been paid during the year by the Boston Elevated Railway Company for the use of the subway:

| | | |
|---|---|---|
| Oct. 1, 1899: | | |
| Net cost of subway | $4,118,763 01 | |
| One quarter's rental | | $50,197 43 |
| Alterations: total cost | 190,895 86 | |
| One quarter's rental | | 2,325 54 |
| Jan. 1, 1900: | | |
| Net cost of subway | 4,126,681 72 | |
| One quarter's rental | | 50,293 93 |
| Alterations: total cost | 192,661 86 | |
| One quarter's rental | | 2,348 07 |
| April 1, 1900: | | |
| Net cost of subway | 4,135,756 10 | |
| One quarter's rental | | 50,404 53 |
| Alterations: total cost | 195,597 59 | |
| One quarter's rental | | 2,383 84 |
| July 1, 1900: | | |
| Net cost of subway | 4,136,178 48 | |
| One quarter's rental | | 50,409 68 |
| Alterations: total cost | 199,486 06 | |
| One quarter's rental | | 2,431 24 |
| Total | | $210,794 26 |

The rental due October 1 will not vary materially from the last quarterly payments.

## Statement of Expenses.

The following is a classified statement of the expenses of the Commission for the year ending Aug. 15, 1900:

### SUBWAY.

| | | |
|---|---|---|
| General Expenses: | | |
| Office — Repairs | $29 50 | |
| Furniture | 117 72 | |
| Supplies | 436 60 | |
| Stationery and printing | 1,236 33 | |
| Rental | 750 00 | |
| Fuel and light | 129 23 | |
| Stenographers | 2,046 66 | |
| Messenger | 594 00 | |
| Clerks | 528 00 | |
| Janitor | 170 77 | |
| Salaries of Commissioners and Secretary | 5,915 00 | |
| Total | | $11,953 81 |
| Transferred to other accounts: | | |
| Charlestown Bridge | $5,393 64 | |
| Alterations | 2,607 73 | |
| East Boston Tunnel | 3,109 21 | |
| | | 11,110 58 |
| Balance on account of subway | | $843 23 |

### Engineering Department.

| | | |
|---|---|---|
| Rooms — Repairs | $1 06 | |
| Supplies | 212 83 | |
| Stationery and printing | 247 05 | |
| Fuel and light | 122 69 | |
| Rental | 1,650 00 | |
| Janitor | 170 78 | |
| Messenger | 135 10 | |
| Stenographers | 450 60 | |
| Supplies | 200 29 | |
| H. A. Carson, Chief Engineer | 166 50 | |
| Skilled service | 1,301 43 | |
| | $4,658 33 | |
| Credit: allowance for furniture | 96 16 | |
| Balance | | 4,562 17 |

### Miscellaneous.

| | | |
|---|---|---|
| Advertising | $50 40 | |
| Labor | 87 84 | |
| | | 138 24 |

### Section Two.

| | | |
|---|---|---|
| Labor | $0 60 | 0 60 |
| *Carried forward* | | $5,544 24 |

| | | | |
|---|---|---|---|
| *Brought forward* | | | $5,544 24 |
| **SECTION FOUR.** | | | |
| Labor | | $41 90 | |
| Skilled service | | 25 00 | |
| Office supplies | | 34 | |
| Field supplies | | 52 00 | |
| Eliot-street sewer; field supplies | | 4 00 | |
| | | | 123 24 |
| **SECTION SIX.** | | | |
| Damages | | $500 00 | |
| Labor | | 4 50 | |
| | | | 504 50 |
| **SECTION SEVEN.** | | | |
| Repaving Tremont street | | $617 47 | |
| Labor | | 1 85 | |
| Chas. Brigham, Architect | | 204 48 | |
| | | | 823 80 |
| **SECTION EIGHT.** | | | |
| Labor | | $3 10 | |
| Field supplies | | 4 00 | |
| | | | 7 10 |
| **SECTION EIGHT AND ONE-HALF.** | | | |
| Labor | | $2 40 | 2 40 |
| **SECTION NINE.** | | | |
| Chas. Brigham, Architect | | $204 49 | |
| Labor | | 12 40 | |
| | | | 216 89 |
| **SECTION TEN.** | | | |
| Repaving Tremont street | | $617 47 | |
| Damages | | 100 00 | |
| Labor | | 11 30 | |
| | | $728 77 | |
| Less special draft No. 560, H. A. Jaynes & Co., withdrawn | | 56 07 | |
| | | | 672 70 |
| **SECTION ELEVEN.** | | | |
| Construction | | $297 22 | |
| Field supplies | | 91 00 | |
| Labor | | 15 00 | |
| Travers-street subway: | | | |
| Construction | $2,339 87 | | |
| Office supplies | 5 75 | | |
| Field supplies | 290 58 | | |
| Labor | 1,306 21 | | |
| Teaming | 25 41 | | |
| Electric conduits | 71 26 | | |
| Gow & Foss | 3,094 64 | | |
| S. D. Hicks & Son | 1,797 00 | | |
| Walter S. Lyons | 657 00 | | |
| W. A. Murtfeldt Co. | 242 25 | 9,829 97 | |
| | | | 10,233 19 |
| *Carried forward* | | | $18,128 06 |

| | | |
|---|---|---|
| *Brought forward* . . . . . | | $18,128 06 |

## ALTERATIONS.

| | | |
|---|---|---|
| General expenses: | | |
| Amount transferred from subway general expenses . . . . . . . . | $2,607 73 | |
| Amount transferred from East Boston tunnel general expenses . . . . | 2,913 37 | |
| Proportion of salary of Chief Engineer . | 2,000 00 | |
| Skilled service . . . . . . . | 98 30 | |
| Office supplies . . . . . . . | 15 03 | |
| Field supplies . . . . . . . | 38 | |
| Messenger . . . . . . . . | 5 34 | |
| Stenographers . . . . . . . | 9 97 | |
| Construction . . . . . . . | 1,205 00 | |
| Labor . . . . . . . . . | 12 15 | |
| Advertising . . . . . . . . | 38 99 | |
| | | 8,906 26 |

### SECTION THREE.

| | | |
|---|---|---|
| Construction . . . . . . . . | $128 00 | |
| Skilled service . . . . . . . | 4 17 | |
| Stenographers . . . . . . . | 5 02 | |
| | | 137 19 |

### SECTION FOUR.

| | | |
|---|---|---|
| Skilled service . . . . . . . | $4 17 | |
| Stenographers . . . . . . . | 2 00 | |
| Labor . . . . . . . . . | 157 25 | |
| | | 163 42 |

### SECTION FIVE.

| | | |
|---|---|---|
| Skilled service . . . . . . . | $480 86 | |
| Office supplies . . . . . . . | 6 14 | |
| Stenographers . . . . . . . | 23 50 | |
| | | 510 50 |

### SECTION SEVEN.

*Easterly platform.*

| | | |
|---|---|---|
| Advertising . . . . . . . . | $232 01 | |
| Relocating pipes . . . . . . . | 351 10 | |
| Office supplies . . . . . . . | 1 67 | |
| Field supplies . . . . . . . | 52 00 | |
| Skilled service . . . . . . . | 25 37 | |
| | | 662 15 |

### SECTION TEN.

| | | |
|---|---|---|
| Stenographers . . . . . . . | $3 66 | |
| Labor . . . . . . . . . | 91 00 | |
| | | 94 66 |

## EAST BOSTON TUNNEL.

| | | |
|---|---|---|
| General Expenses: | | |
| Office — Repairs . . . . . . | $20 56 | |
| Supplies . . . . . . | 152 22 | |
| Stationery and printing . . | 43 21 | |
| Rental . . . . . . . | 750 00 | |
| Fuel and light . . . . | 63 40 | |
| *Carried forward* . . . . . | $1,029 39 | $28,602 24 |

| | | | |
|---|---|---|---|
| *Brought forward* | | $1,029 39 | $28,602 24 |
| Stenographers | | 1,112 10 | |
| Messenger | | 342 00 | |
| Clerks | | 304 00 | |
| Janitor | | 98 33 | |
| Salaries of Commissioners and Secretary | | 11,670 00 | |
| | | $14,555 82 | |
| Transferred to other accounts: | | | |
| Charlestown Bridge | $5,101 11 | | |
| Alterations | 2,913 37 | 8,014 48 | |
| Balance General Expenses; East Boston Tunnel | | $6,541 34 | |
| Amount transferred from subway general expenses | | 3,109 21 | |
| Proportion of Salary of Chief Engineer | | 5,833 50 | |
| | | | 15,484 05 |

ENGINEERING DEPARTMENT.

| | | |
|---|---|---|
| Rooms — Repairs | $7 79 | |
| Furniture | 1 25 | |
| Supplies | 742 71 | |
| Stationery and printing | 409 53 | |
| Fuel and light | 59 59 | |
| Rental | 750 00 | |
| Janitor | 98 32 | |
| Messenger | 323 85 | |
| Stenographers | 1,158 85 | |
| Supplies | 313 72 | |
| Skilled service | 8,405 53 | |
| | | 12,271 14 |

MISCELLANEOUS.

| | | |
|---|---|---|
| Advertising | $3 75 | |
| Labor | 1,150 28 | |
| Legal and expert advice | 4,299 65 | |
| E. A. Clark, borings | 1,172 87 | |
| B. F. Smith & Bro., borings | 32 88 | |
| Teaming | 23 65 | |
| | | 6,683 08 |

SECTION A.

(*In Maverick square and Lewis street, East Boston, to a point 100 feet south-west of Webster street.*)

| | | |
|---|---|---|
| National Contracting Company | $26,229 60 | |
| Construction | 1,407 09 | |
| Advertising | 115 83 | |
| Office supplies | 107 99 | |
| Field supplies | 719 90 | |
| Stationery and printing | 120 54 | |
| Labor | 120 34 | |
| Teaming | 7 50 | |
| Rental | 45 00 | |
| Repairs | 15 00 | |
| Skilled service | 10 25 | |
| | | 28,899 04 |
| *Carried forward* | | $91,939 55 |

| | | |
|---|---|---|
| *Brought forward* . . . . . | | $91,939 55 |

SECTION B.

(*From a point in Lewis street 100 feet south-west of Webster street, East Boston, under harbor between South Ferry slips, Fleet and Hanover streets to about 170 feet south-west of Prince street.*)

| | | |
|---|---|---|
| Advertising . . . . . . . . | $210 58 | |
| Office supplies . . . . . . . | 110 97 | |
| Field supplies . . . . . . . | 139 17 | |
| Labor . . . . . . . . . | 194 81 | |
| Teaming . . . . . . . . | 7 00 | |
| Stationery and printing . . . . . . | 49 55 | |
| Legal and expert advice . . . . | 20 00 | |
| | | 732 08 |

CHARLESTOWN BRIDGE.

| | | |
|---|---|---|
| General Expenses: | | |
| Transferred from East Boston Tunnel General Expenses . . . . . | $5,101 11 | |
| Transferred from Subway General Expenses . . . . . . . . | 5,393 64 | |
| | | 10,494 75 |
| D. J. Kiley & Co. (Painting) . . . . | $2,741 15 | |
| W. H. Ellis (Draw fender pier) . . . . | 16,497 00 | |
| Jones & Meehan . . . . . . . | 2,710 02 | |
| Granolithic sidewalks . . . . . . | 4,486 74 | |
| Land damages . . . . . . . | 234,404 30 | |
| Grade damages . . . . . . . | 14,620 74 | |
| Stationery and printing . . . . . . | 574 42 | |
| Construction . . . . . . . . | 36,865 01 | |
| Office supplies . . . . . . . | 222 64 | |
| Field supplies . . . . . . . | 11,393 95 | |
| Advertising . . . . . . . . | 187 01 | |
| Labor . . . . . . . . . | 9,173 27 | |
| Legal and expert advice . . . . . | 1,145 00 | |
| Teaming . . . . . . . . | 1,524 02 | |
| Skilled service . . . . . . . | 8,318 11 | |
| Electric lighting . . . . . . . | 814 45 | |
| William Jackson, Chief Engineer . . . | 1,833 00 | |
| | | 347,510 83 |
| Grand total . . . . . . . | | $450,677 21 |

## SUMMARY.

| | From beginning of work to Aug. 15, 1899. | Aug. 15, 1899, to Aug. 15, 1900. | Total. |
|---|---|---|---|
| Subway — Subway Commission . . . | $14,131 16 | | $14,131 16 |
| Part of General Expenses . . . | 116,464 06 | $843 23 | 117,307 29 |
| Engineering and Miscellaneous . . . | 401,552 06 | 4,700 41 | 406,252 47 |
| Section One . . . | 240,594 76 | | 240,594 76 |
| Two . . . | 364,172 60 | 60 | 364,173 20 |
| Three . . | 307,910 63 | | 307,910 63 |
| Three and one-half . . | 9,479 39 | | 9,479 39 |
| Four . . . | 475,987 07 | 123 24 | 476,110 31 |
| Five . . . | 387,438 54 | | 387,438 54 |
| Six . . . | 327,047 11 | 504 50 | 327,551 61 |
| Seven . . | 235,662 59 | 823 80 | 236,486 39 |
| Eight . . | 100,058 69 | 7 10 | 100,065 79 |
| Eight and one-half . . | 77,464 64 | 2 40 | 77,467 04 |
| Nine . . . | 309,673 13 | 216 89 | 309,890 02 |
| Ten . . . | 256,686 19 | 672 70 | 257,358 89 |
| Eleven . . | 258,998 24 | 10,233 19 | 269,231 43 |
| Interest . . . . | 258,575 60 | | 258,575 60 |
| Total . . . . | $4,141,896 46 | $18,128 06 | $4,160,024 52 |
| Alterations — Part of General Expenses . . | $13,366 61 | $8,906 26 | $22,272 87 |
| Section Three . . | 2,391 07 | 137 19 | 2,528 26 |
| Four . . . | | 163 42 | 163 42 |
| Five . . . | 87 48 | 510 50 | 597 98 |
| Seven . . | 172,609 14 | 662 15 | 173,271 29 |
| Nine . . . | 3 00 | | 3 00 |
| Ten . . . | 439 38 | 94 66 | 534 04 |
| Interest . . . . | 1,905 56 | | 1,905 56 |
| Total . . . . | $190,802 24 | $10,474 18 | $201,276 42 |
| East Boston Tunnel — Part of General Expenses . | $19,148 70 | $15,484 05 | $34,632 75 |
| Engineering Expenses . | 30,644 79 | 18,954 22 | 49,599 01 |
| Section A . . . | 855 14 | 28,899 04 | 29,754 18 |
| B . . . | | 732 08 | 732 08 |
| Total . . . . | $50,648 63 | $64,069 39 | $114,718 02 |
| Bridge — Part of General Expenses . . . | $40,710 18 | $10,494 75 | $51,204 93 |
| Engineering Expenses . | 1,054,568 28 | 347,510 83 | 1,402,079 11 |
| Total . . . . | $1,095,278 46 | $358,005 58 | $1,453,284 04 |
| Grand Total . . | $5,478,625 79 | $450,677 21 | $5,929,303 00 |

The reports of the Chief Engineer and of the Chief Engineer for Charlestown Bridge are appended.

GEORGE G. CROCKER,
CHARLES H. DALTON,
THOMAS J. GARGAN,
GEORGE F. SWAIN,
HORACE G. ALLEN,

*Boston Transit Commission.*

# REPORT OF THE CHIEF ENGINEER.

BOSTON, Aug. 15, 1900.

GEORGE G. CROCKER, CHARLES H. DALTON, THOMAS J. GARGAN, GEORGE F. SWAIN, HORACE G. ALLEN, *Boston Transit Commissioners:*

GENTLEMEN: I herewith submit a report on the East Boston Tunnel, together with statements and remarks in relation to other matters.

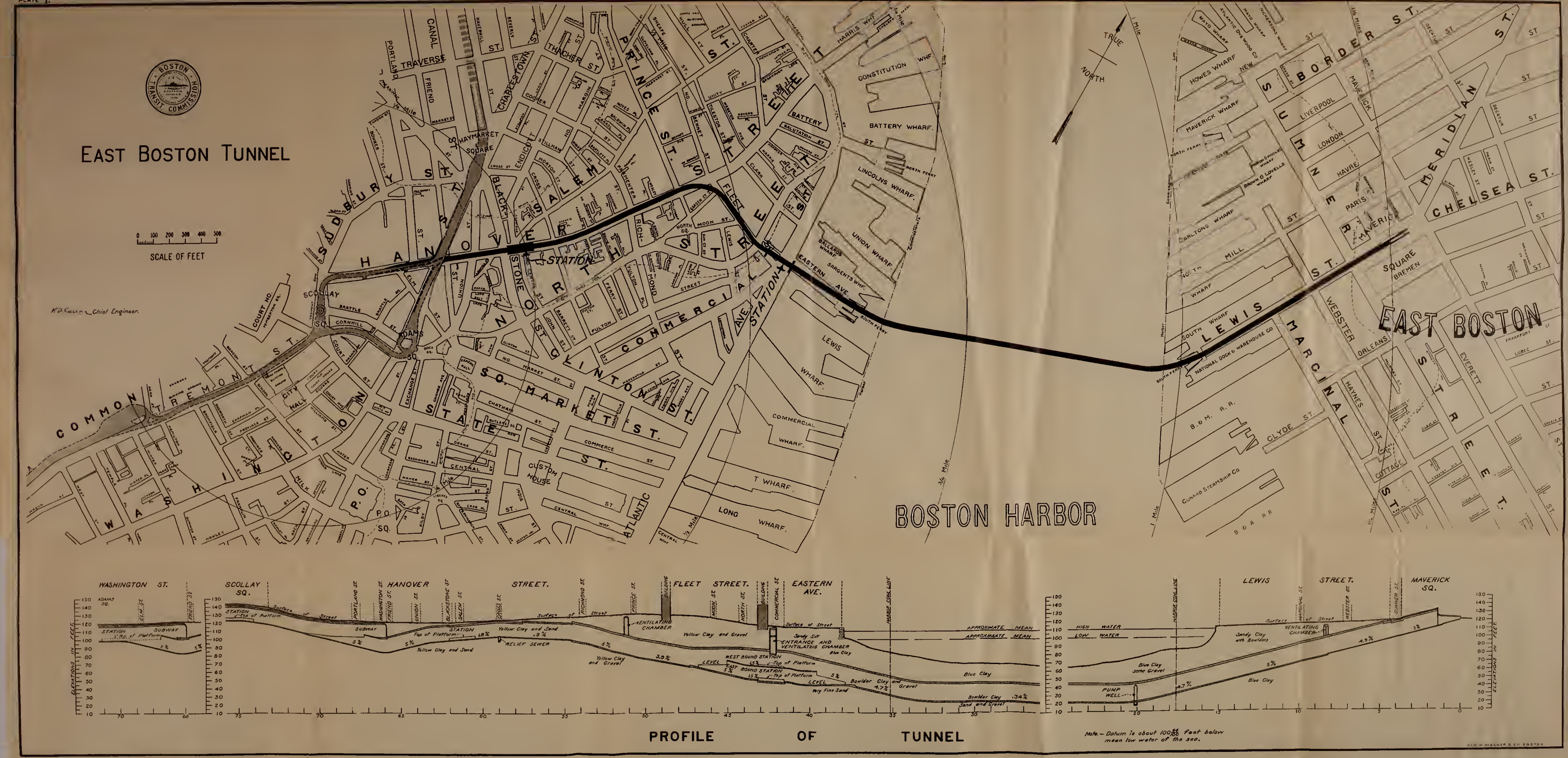
## EAST BOSTON TUNNEL.

In our earlier discussions and studies it was assumed that the tunnel for a length of upwards of 3,000 feet under and near the harbor would consist of two narrow tubes each of about 16 feet internal diameter. The southerly of these tubes would contain a track for cars passing to East Boston and the northerly would contain one for those returning. Tubes of much less diameter than these are in use in Great Britain as passenger tunnels. In the first electric railway tunnel built in London, the City and South London, the twin tubes under the Thames are each only 10 feet 2 inches in internal diameter; the Waterloo and City Railway (London) has an internal diameter on straight lines of 12 feet $1\frac{3}{4}$ inches and on curves of 12 feet 9 inches; the latest one built, the Central London Railway, has tubes of 11 feet 6 inches diameter; and the twin tubes of the Glasgow District subway are only 11 feet. Various estimates have been made comparing the differences between twin tubes 16 feet in diameter and a single wider tube having an internal diameter of about 23 feet. The Commission concluded that although a wide tube would be more costly and would have less favorable grades than twin narrow ones it would conduce more to the comfort of passengers, would be much more satisfactory to the public, and would be more in accordance with the work previously done by the Commission, and after a full discussion of the subject a wide tunnel was adopted.

### BUILDING MATERIAL FOR WALLS OF THE TUNNEL.

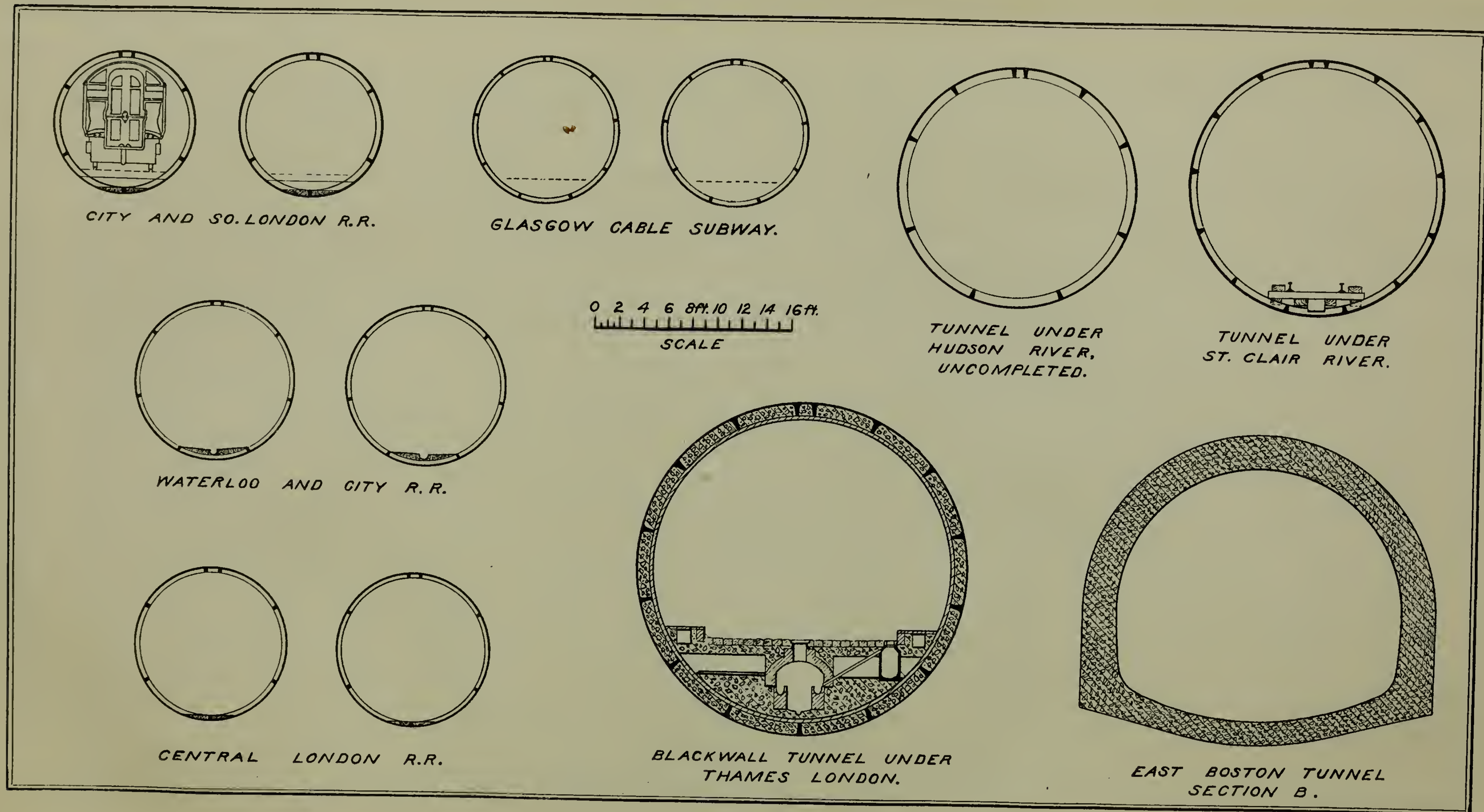
The walls of the Blackwall tunnel under the Thames (which structure is about one foot wider inside and two feet narrower outside than the East Boston tunnel) are constructed of cast-iron segments bolted together. The walls of

PLATE I.



BOSTON TRANSIT COMMISSION
EAST BOSTON TUNNEL
SCALE OF FEET
0 100 200 300 400 500
Chief Engineer.
TRUE NORTH
BOSTON HARBOR
EAST BOSTON
HANOVER ST.
NORTH ST.
FLEET ST.
COMMERCIAL ST.
SUDBURY ST.
SALEM ST.
PRINCE ST.
CLINTON ST.
SO. MARKET ST.
STATE ST.
WASHINGTON ST.
TREMONT ST.
COMMON
SCOLLAY SQ.
HAYMARKET SQUARE
ADAMS SQ.
P.O. SQ.
CUSTOM HOUSE
EASTERN AVE.
STATION
LEWIS ST.
SUMNER ST.
BORDER ST.
MERIDIAN ST.
CHELSEA ST.
MARGINAL ST.
MAVERICK SQUARE
BATTERY WHARF
CONSTITUTION WHF.
LINCOLNS WHARF
UNION WHARF
LEWIS WHARF
COMMERCIAL WHARF
T WHARF
LONG WHARF
CUNARD STEAMSHIP CO.
NATIONAL DOCK & WAREHOUSE CO.
PROFILE OF TUNNEL
WASHINGTON ST.
SCOLLAY SQ.
HANOVER STREET.
FLEET STREET.
EASTERN AVE.
LEWIS STREET.
MAVERICK SQ.
ELEVATIONS IN FEET.
HIGH WATER
LOW WATER
APPROXIMATE MEAN
Yellow Clay and Sand
Yellow Clay and Gravel
Blue Clay
Bowlder Clay and Gravel
Sandy Clay with Bowlders
VENTILATING CHAMBER
ENTRANCE AND VENTILATING CHAMBER
WEST BOUND STATION
EAST BOUND STATION
PUMP WELL
HARBOR COM. LINE
Note.— Datum is about 100 feet below mean low water of the sea.

PLATE IA.




RELATIVE SIZES OF VARIOUS TUNNELS.

the London and Glasgow electric and cable railway tunnels referred to on the previous page are also built in the same way, and the same is true of the St. Clair tunnel and of the most recent portion of the unfinished tunnel which has for some years lain drowned under the Hudson. In most of the earlier studies for the East Boston tunnel a similar construction was contemplated. The great rise in the cost of iron which took place about two years ago led to the consideration of concrete as a substitute. Concrete has been employed as a building material for centuries and owing to the improvement in Portland cement its use during the last two or three decades has grown very rapidly and appears likely to continue to increase for many years to come. There has also been considerable experience as to advantageous methods of using steel and iron in connection with concrete so as to form economical and effective combinations. Segments of cast-iron such as were used in the tunnels referred to above have important advantages. They can be bolted together so as to form the walls of the tunnel in a manner comparatively simple and easy and in such a way as to interfere but little with the operations of excavation. The full strength of the walls so built is to be had immediately and they form excellent supports for the hydraulic jacks to push against in moving the tunneling shield forward. They have a further advantage in very wet ground that they can be calked so as to leak but little.

Concrete walls must necessarily be made thicker than cast-iron ones; they must be built on centering, which occupies appreciable space; difficulties requiring ingenuity to overcome exist in the matter of keying up, etc.; shrinkage cracks are to be expected through which in wet ground leakage may occur unless adequately provided against; the full strength of the concrete is not obtained until more than a year after it is made, and while the necessary strength is being reached centres and bracing must be kept in place. About one-half the full strength of the concrete, however, is reached in less than one month, and in general, centres and bracing need not remain in place longer than that. In the matter of durability concrete has rather more chances in its favor than cast-iron, and in the matter of cost the difference in favor of concrete where it is feasible to use it is very great. Shrinkage cracks in the tunnel can be wholly or partially closed, and for a considerable portion of the length of the East Boston tunnel and perhaps for nearly all of it the walls will be surrounded by such compact and excellent clay that a great amount of leakage is not to be expected.

It is proposed in the East Boston tunnel to make use of concrete to such an extent as the conditions there developed shall warrant. It is also proposed to combine steel with the concrete to such an extent as shall prove necessary and in such manner as shall be effective and economical and as shall be found convenient in progressing with the work. Cast-iron segments bolted together combined with steel ribs may be used where the ground is such that a great amount of leakage is to be apprehended, or where for any reason they may be desirable.

## Lowering of the Profile.

As shown on the profiles of the plans originally made for Section B, the central portion of the tunnel about 1,350 feet long had the top of its masonry 45 feet or more below mean low water. At the Harbor Commissioners' lines it was only a little over 35 feet below. This made greater allowance for deepening the harbor than was thought ample by United States Engineer officers stationed at this port at the time the depths were fixed. A bill enacted this summer by Congress authorized a survey for a 35-ft. depth between the Harbor Commissioners' lines and for a channel 2,000 feet wide going down to the entrance of the harbor. If the dredging is carried out as planned the tunnel according to the original profile would be completely uncovered at the Harbor Commissioners' lines and would be liable to injury. The Commission decided, May 31, 1900, to change the profile for Section B so as to make the tunnel at the shore ends about 9½ feet lower — also involving a like lowering of the south-westerly end of Section A. This lowering of the position of the tunnel of course increases the length of the already long and steep shore inclines, but it will allow a harbor depth of more than 40 feet at low water without danger to the tunnel. A length of about 1,000 feet under the middle of the channel remains at the depth given before. The position for the tunnel on the East Boston side will, it is thought, be in better material for tunnel excavation than before.

## Borings.

Two hundred and six borings have been made to reveal the character of the ground in and near the proposed route of this tunnel. Twenty-two of these were made during the last year, varying in depth from 20 to 60 feet, 11 being made on land and 11 in the harbor. A few (through bowlders) were made with a diamond drill. An interesting and unexpected observation was made in connection with

one of the borings near the slip of the South Ferry on the Boston side. After boring through blue clay to a depth of 43 feet below the bottom of the harbor a vein of coarse sand 2.9 feet thick was struck which caused the level of the water in the boring pipe to fall and remain about 7 feet below the level of the water of the harbor.

## WORK DONE ON SECTION A OF THE EAST BOSTON TUNNEL (CONTRACT WORK) DURING THE YEAR ENDING AUGUST 15, 1900.

*Location.* — In Maverick square and Lewis street, East Boston — beginning in the square nearly opposite Winthrop street and ending in Lewis street 100 feet southwest of Webster street.

*Contractor for Construction.* — National Contracting Company of New York; Wm. Mayo Venable, Local Manager; Wm. J. Lang, Superintendent.

*Transit Commission Engineers.* — John E. Palmer, Assistant Engineer; William O. Wellington, transitman; Samuel Rosnosky, John H. Graham, rodmen. Frank J. Eager, Charles C. Johnson, and Chester N. Chubb have assisted Mr. Palmer in inspecting concrete and in other details of construction.

| Date of contract. | Date of beginning work. | Date when section should be completed. |
|---|---|---|
| April 24, 1900. | May 5, 1900. | About Nov. 21, 1900. |

*General Description of Structure.* — The structure is for two electric railway tracks and consists of 139 feet of open incline and 680 feet of wide-arch subway. The side-walls of the incline are of concrete faced with granite and surmounted by a granite coping. Granite also surrounds the portal. The subway or covered portion of this section is a concrete monolith. Nuts and washers are imbedded in the masonry to admit of the use of steel tie-rods for increasing the strength of the roof if deemed desirable. This section is at a grade of practically 5 per cent. for its whole length, and at its southwesterly end the bottom of the masonry invert is about 39 feet below the surface of the street.

*Method of Doing Work.* — The drinking fountain and flagstaff near the site of the incline were moved northerly to Maverick street and reset. The tunnel is very near the surface between Sumner and Webster streets, and the service water-pipes if laid over the structure would have been too near the surface to be protected from frost. A new 6-inch main was accordingly laid on the northwesterly side of Lewis street between these points, the Commission's men doing the digging and the Water Department laying the pipe. All of the excavating on Section A has been done by open cut. The excavating for the incline in Maverick square was

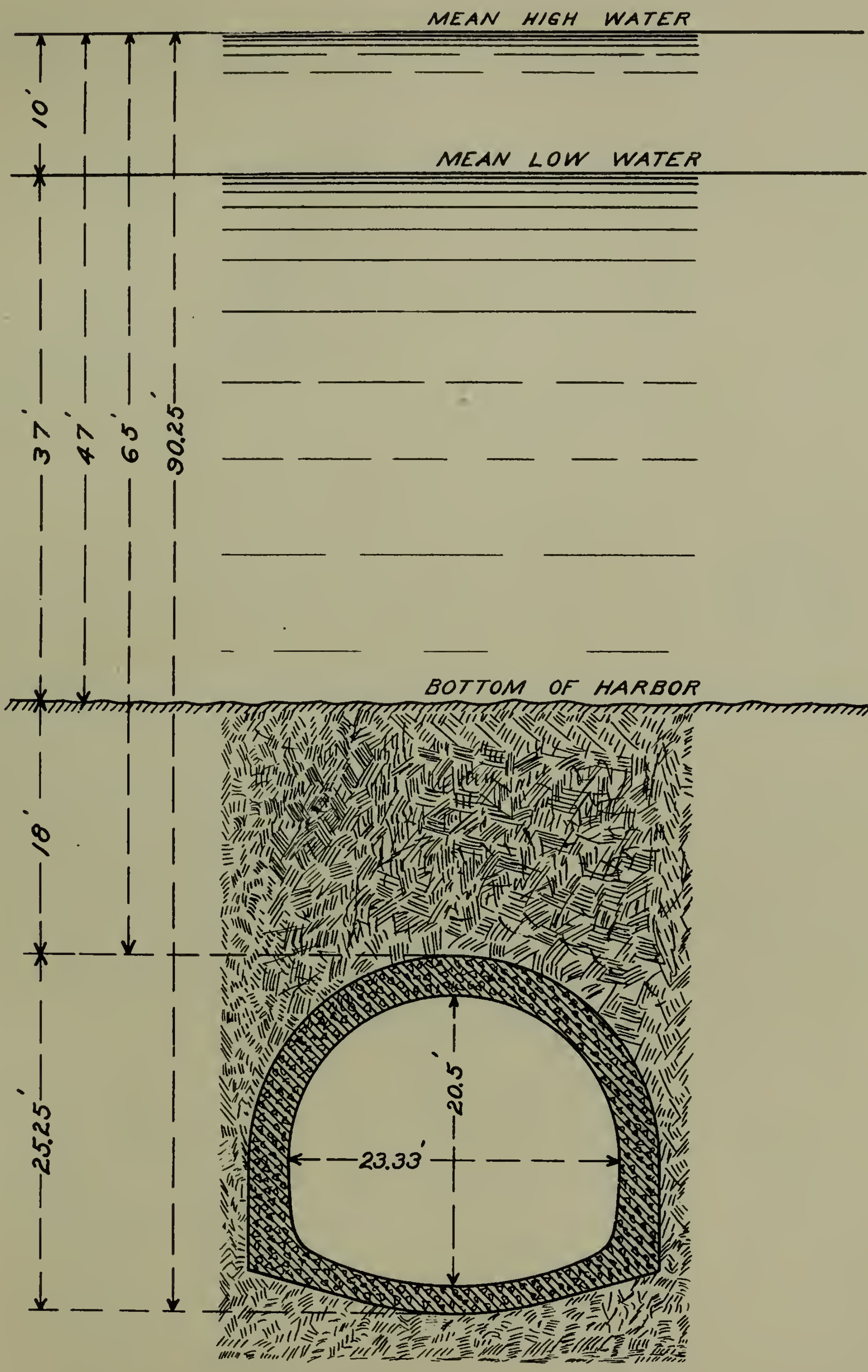
done without timbering the trench and the earth was shovelled into carts. In Lewis street the trench has been braced for its full width. In this Lewis street portion of the work the first ten feet of depth of excavation has been shovelled directly into carts, and below this depth the excavated material has been handled by a cable-way. The surplus earth has been readily disposed of in the vicinity of the work — most of it being used to fill in a dock and some as filling on flats of the East Boston Company.

In preparing to put in place the masonry for the covered portion the bottom of the excavation was graded and three thicknesses of tarred felt were laid. They were so placed as to lap 6 inches, and were thoroughly pitched together, and the surfaces were mopped until entirely covered. When the pitch had sufficiently hardened the concrete invert was put in and 6-inch back walls were carried up a convenient distance, the sheeting being removed and the trench rebraced as was necessary. The back walls were plastered with a rich Portland cement plaster, and against this the main wall was built. These operations were repeated until walls were completed to the springing line of the arch. Wooden centres were used and work on each section of the concrete arch was carried on continuously until its completion. The arch was allowed to set about 12 hours when the outside lagging was taken off and the arch plastered so as to join the plaster of the back walls. A 4-inch layer of concrete was put on above the plaster to protect it from future excavators. The plaster was roughened with a corrugated roller, made for the purpose, to assure a bond with the following layer of concrete. Most of the concrete has been made with a Barber mixer.

So far as has been practicable the excavation, laying tarred felt, putting in concrete inverts walls and arches, has been in 12-ft. sections — one operation closely following the other. Centres were usually left in place, from the time the arch was turned, for ten days in Maverick square and thirty days in Lewis street. In some cases the centres in heavily loaded sections were struck soon after turning, in order to note the effect. As the arches on this section are made entirely of concrete, and as tie-rods have not yet been placed in them, and as the experience gained on Section A will be available on other portions of the tunnel, careful observations have been made to notice the amount of change of shape, etc. Some observations will be taken to note the effect of expanded metal, twisted rods and metal in other shapes imbedded in the concrete.

Backfilling over the arch was begun as soon as the lagging was removed from the outside 4-inch layer of concrete, and

PLATE 1 B.



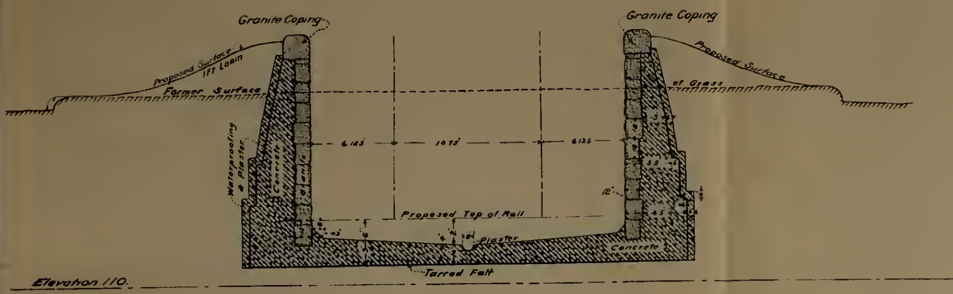

CROSS SECTION SHOWING DEPTH OF TUNNEL ABOUT 800 FEET WEST OF EAST BOSTON SOUTH FERRY SLIP.

H. A. Carson Chief Engineer.

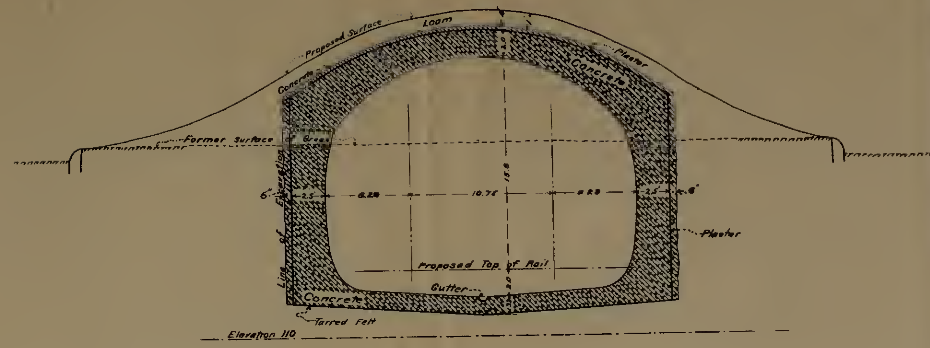
GEO. H. WALKER & CO. BOSTON

PLATE 2.

CROSS SECTION
AT STA. 1+37




CROSS SECTION NO. 5
AT STA. 1+44

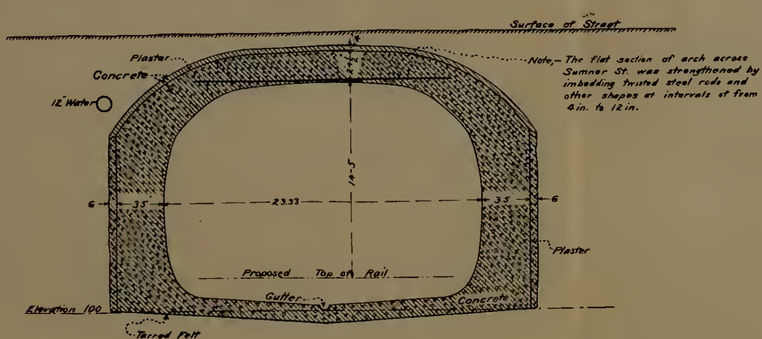



CROSS SECTIONS SECTION A, EAST BOSTON TUNNEL.

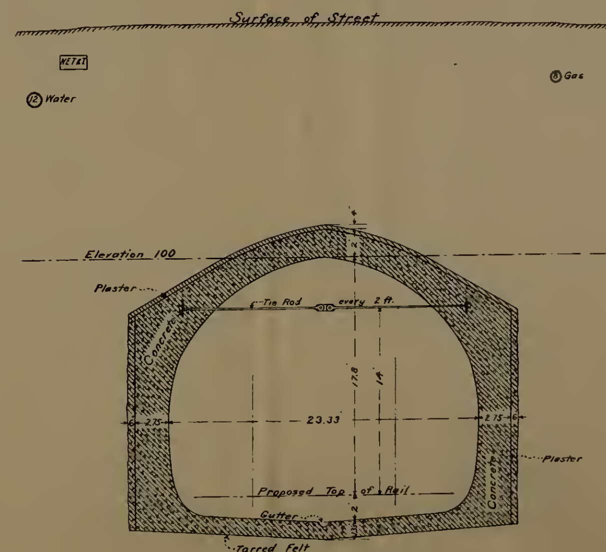
SCALE

H. A. Carson, Chief Engineer

CROSS SECTION
AT STA. 3+88
SUMNER ST.




CROSS SECTION
AT STA 8+0
LEWIS ST.




GEO. H. WALKER & CO. BOSTON

PLATE 3.

SECTION A OF THE EAST BOSTON TUNNEL—TRENCH, BACK-WALL, PORTION OF ARCH NEAR PORTAL AND OPEN INCLINE, MAVERICK SQUARE. JULY 25, 1900.

PLATE 4.

SECTION A OF THE EAST BOSTON TUNNEL, VIEW FROM NEAR PORTAL (LOOKING SOUTHEASTERLY). AUG. 2, 1900.

PLATE 5.


SECTION A OF THE EAST BOSTON TUNNEL, FLATTENED ARCH NEAR SUMNER STREET (LOOKING SOUTHEASTERLY). SEPT. 14, 1900.

PLATE 6.

SECTION A OF THE EAST BOSTON TUNNEL, VIEW UP INCLINE IN MAVERICK SQUARE (LOOKING NORTHEASTERLY). SEPT. 6, 1900.

PLATE 7.

SECTION A OF THE EAST BOSTON TUNNEL, INCLINE AND PORTAL IN MAVERICK SQUARE
(LOOKING SOUTHEASTERLY). AUG. 2, 1900.

this filling was thoroughly and carefully rammed. The filling used over the arch was brought in buckets by means of the cable-way from the point where excavation was going on.

*Progress.*

| ITEMS. | Date of beginning. | Amount of work done during year ending Aug. 15, 1900. | Average rate of progress per week. | Estimated total quantities in section. |
|---|---|---|---|---|
| | 1900 | | | |
| Excavation...... | May 5. | 13,290 cu. yds. | 886 c. y. | 20,300 c. y. |
| Concrete......... | June 13. | 2,180 " " | 242 " " | 5,500 " " |
| Stone masonry .. | June 21. | 55 " " | 7 " " | 60 " " |
| Coping .......... | July 5. | 21 " " | 3 " " | 34 " " |
| Tarred felt...... | June 16. | 2,980 sq. " | 330 sq. " | 9,500 sq. " |
| Waterproofing .. | June 23. | 207 " " | 34 " " | 207 " " |
| Plastering ...... | June 17. | 2,070 " " | 260 " " | 3,000 " " |

The force ordinarily employed with the work well under way has been about 140 men and 10 teams — the work being carried on in one shift. Operations begin at 7 o'clock in the morning, and have frequently been kept up until 9 to 11 o'clock at night in order to insure the continuity in concrete work referred to in a preceding paragraph.

*Character of excavation, etc.* — A filled-in stratum (mainly yellow clay) was found through most of the section, varying from about 3 feet thick in Maverick square to 12 feet thick at the southwesterly end. Between Webster street and the southwesterly end of the section some silty sand was found with its surface from 12 to 25 feet below the surface of the street. Below this stiff blue clay and above this yellow clay was found. The silty sand contained some considerable water which was affected by the tide. This water came into the trench at the approximate rate of 6,000 gallons per twenty-four hours. The pumping has been done by the occasional use of a No. 6 Knowles pump and two Edson diaphragm hand pumps. There have been slight settlements of the surface near the southerly end of the section.

## SECTION B OF THE EAST BOSTON TUNNEL (CONTRACT WORK).

*Location.* — Beginning at a point in Lewis street, 100 feet southwest of Webster street, East Boston, it runs under Lewis street, Boston harbor between the South Ferry slips, and on the Boston side under Eastern avenue, Fleet and Hanover streets to a short distance beyond Prince street. The thickness of the roof of earth over the outside of the arch of the tunnel under the harbor will be from 16 to 18 feet, above which in the deepest part of the harbor will be about 35½ feet of water at mean low tide. The total length of the section is about 4,430 feet. If the contractor so desires the contract section will be extended a further distance of about 100 feet to near Richmond street.

*Contractors for Construction.* — The Boston Tunnel Construction Company. Michael Tallent is superintendent.

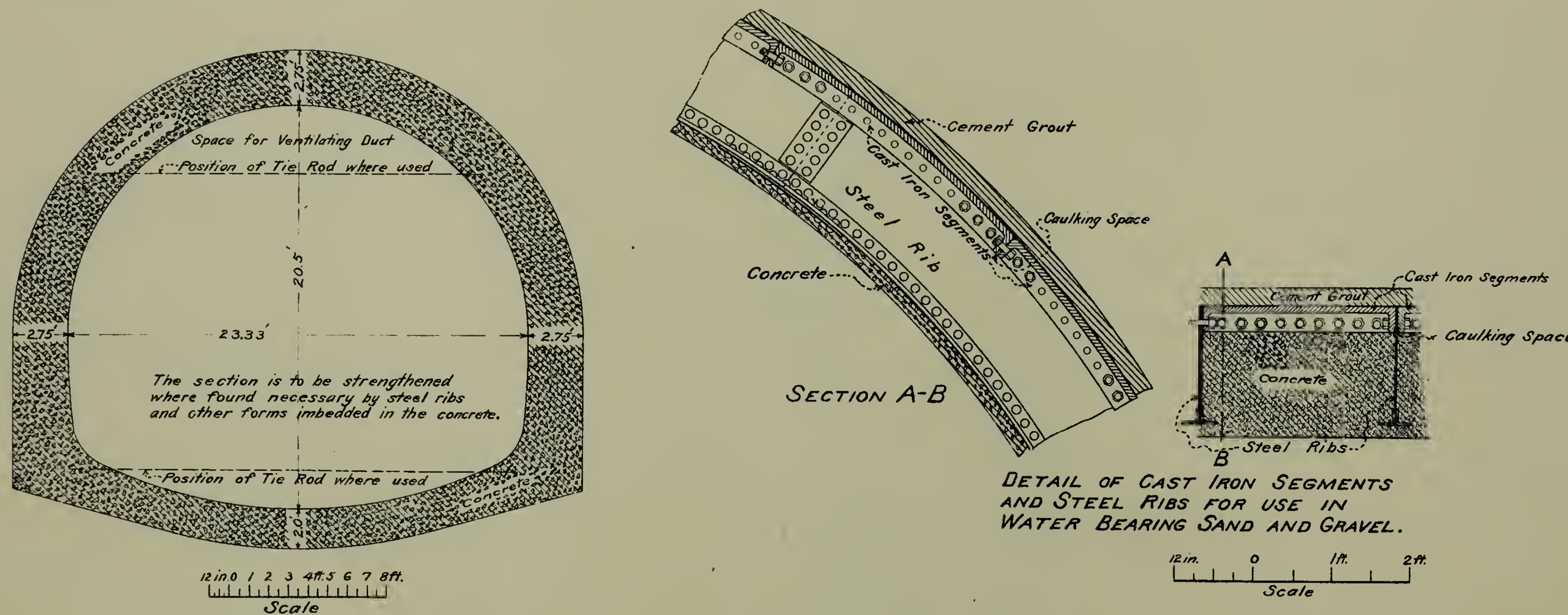
*Transit Commission Engineers.* — John E. Palmer, Assistant Engineer; William O. Wellington, transitman; Samuel Rosnosky, John H. Graham, rodmen.

| Date of contract. | Date of beginning excavation (shaft in Lewis street). | Date of completion named in contract. |
|---|---|---|
| June 28, 1900. | Aug. 13, 1900. | June 15, 1903. |

*General Description of Proposed Structures.* — The tunnel will be an arched structure for two electric railway tracks. The portion under the harbor will be about 20½ feet high inside and about 23 feet wide and about 2,250 feet long, and has walls of 33 inches and upwards in thickness. The tunnel on the East Boston side has grades of from 4.7 to 5 per cent. and at a point 250 feet southwesterly from the Harbor Commissioners' line is about 100 feet lower than in Maverick square. A length of about 1350 feet in mid harbor is nearly level. Grades of 5 per cent. occur on the Boston side but are of short lengths owing to the intervention of the Commercial-street station. At this point the platform for the west-bound cars is immediately above that for the east-bound, their depths below the street being respectively about 50 and 66½ feet. Pump wells and chambers under the harbor and ventilating chambers on each side of the harbor are included in the section. Ventilation of that portion of the tunnel under the harbor will be effected with the aid of a segmental duct of about 45 square feet area in the top of the tunnel. Near the middle of the harbor this duct will communicate with the tunnel underneath by a door. The shore ends of the duct will open into ventilating chambers through which the air can be drawn out. The air will enter from the open end of the tunnel in Maverick square and at or near the Commercial-street station will pass through the main body of the tunnel, enter the door in the duct referred to, and, returning to the shores, will pass out as described. Refuge niches are to be built at frequent intervals in each side wall of the tunnel.

*Proposed Method of Carrying on the Work.* — The shaft which has just been started in Lewis street will be sunk to grade and then side-walls will be commenced in small tunnel drifts. A steel roof-shield will span these side-walls and will be pushed forward on them by the use of hydraulic jacks. As the roof-shield is advanced step by step the arch will be put in place inside. After the tunnel has been built for a hundred feet or more an air lock will be built, and thenceforward during construction the air will be compressed to such an extent as may be necessary to prevent any objectionable flow of water into the working portion of the tunnel.

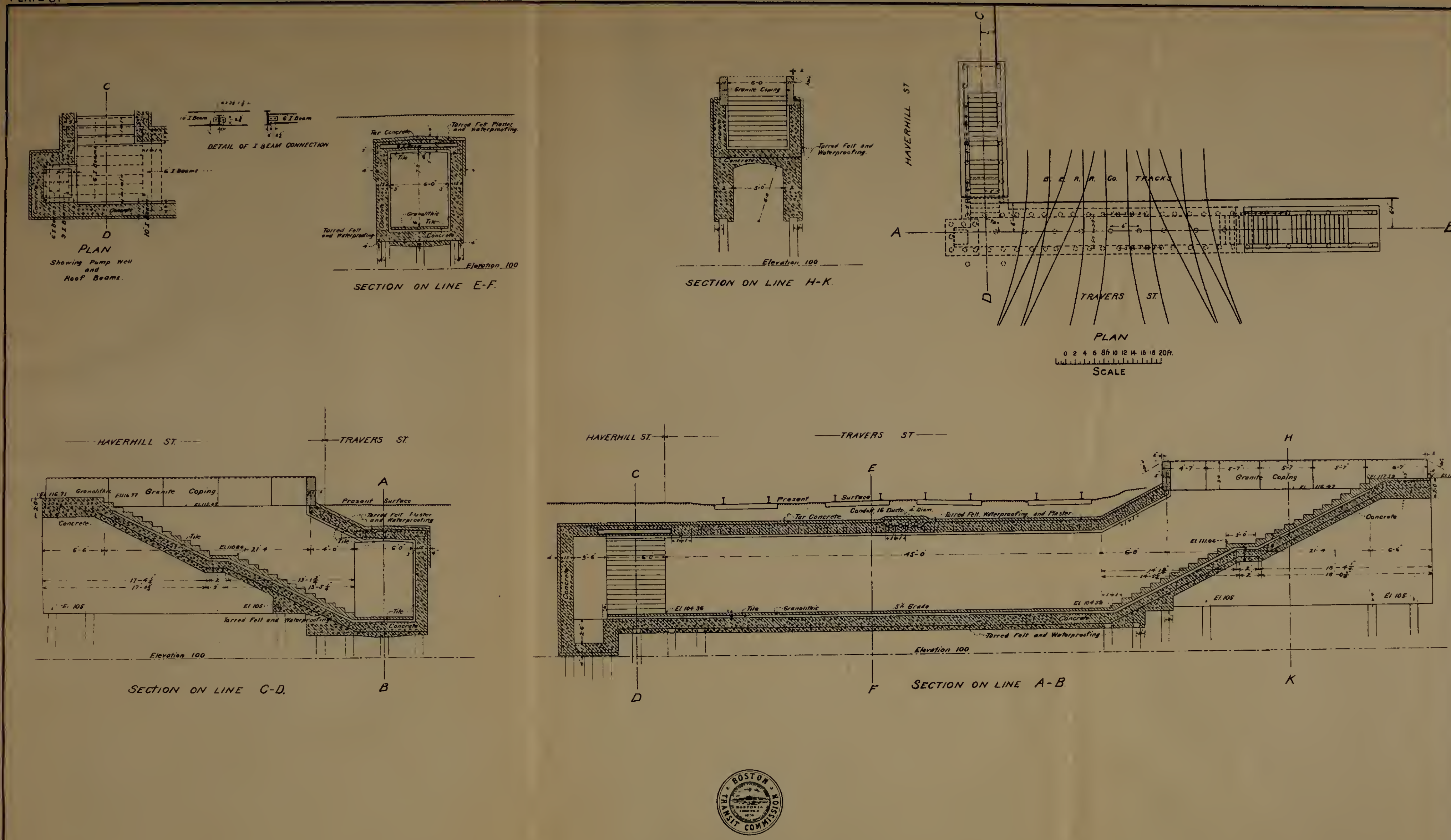
PLATE 8.




OUTLINES OF CROSS SECTIONS OF
SECTION B, EAST BOSTON TUNNEL.

H. A. Carson Chief Engineer

GEO. H. WALKER & CO. BOSTON.




PASSAGEWAY UNDER TRACKS
AT TRAVERS ST.

H. A. Carson Chief Engineer

GEO. H. WALKER & CO. BOSTON

## PASSAGEWAY FOR FOOT-PASSENGERS UNDER TRACKS OF THE BOSTON ELEVATED RAILWAY COMPANY AT TRAVERS STREET.

*Contractors.*

Excavation, piles in place, concrete masonry, setting steel I-beams, tar concrete on roof, waterproofing, etc., GOW & FOSS, 8 Exchange place, Boston.

Furnishing granite coping, WALTER S. LYONS, 256 Swett street, Boston.

Furnishing opalite tile, THE OPALITE TILE COMPANY, Smith building, Pittsburg, Pa.

Furnishing all material for and attaching to the granite foundation two stairway coverings of steel, glass, and copper, S. D. HICKS & SON, 9 Bowker street, Boston.

Furnishing and putting in place artificial stone for floor, stairs, and landings, and setting strips of Mason Safety Tread, W. A. MURTFELDT COMPANY, 192 Devonshire street, Boston.

Furnishing and putting in place doors, casings and handrails, ISAAC McLEAN, 31 and 33 Lancaster street, Boston.

*Table of Progress.*

| | Date of contract. | Final certificate given. |
|---|---|---|
| Construction of main structure . . | Oct. 16, 1899. | Nov. 17, 1899. |
| Stairway coverings . . . . . . . | Oct. 26, 1899. | Dec. 23, 1899. |
| Artificial stone . . . . . . . . . | Dec. 22, 1899. | Jan. 19, 1900. |

The portion of Travers street between Canal street and Haverhill street was discontinued (in accordance with the Statutes of 1894 and 1897) by the votes of the Commission of July 12 and Aug. 30, 1898. The passageway which is described below (under four tracks of the Boston Elevated Railway Company) was built to allow foot-passengers to pass under this discontinued portion of the street.

The plan of this structure is L-shaped, the short leg being formed by the stairway parallel to Haverhill street. Its width inside is 6 feet, its internal height is 7 feet 8 inches, and its length from the foot of one stairway to the foot of the other one is about 50 feet. It is built mainly of concrete, has its roof strengthened by steel I-beams, rests on piles, and its sides and ceiling are lined with vitreous tile. Its floor is of artificial stone, and over each of its two stairways is a covering of glass, steel, and copper. Incorporating in the structure tarred felt, asphalt, and plastering of hydraulic cement mortar and the placing of tar concrete pavement over the roof tend to prevent the entrance of water. A small sump and pumps allow any water which may enter to be discharged into a neighboring sewer. The passageway is lighted by incandescent electric lamps. The total cost was about $10,800. Illustrations of the structure are given on plate 9.

## CHANGES IN THE SUBWAY NEAR PLEASANT STREET FOR CONNECTION WITH THE ELEVATED TRACKS.

A variety of alternative plans have been made for these changes. All except one made provision for allowing street surface cars in addition to elevated cars to enter the Subway at Pleasant street. It was decided, however, to adopt the plans which did not permit the surface cars to enter. Advertisement will shortly be made for bids for the excavation and for changes in foundations, steel work, retaining walls, etc., in accordance with the approved plans, and this work will probably be nearly or quite completed before the first of next January. Its cost is estimated at about $30,000. This estimate does not include the stairways and the building for a passenger waiting-room, etc., which will be constructed later.

Respectfully submitted,

H. A. CARSON,
*Chief Engineer.*

# REPORT OF THE CHIEF ENGINEER FOR CHARLESTOWN BRIDGE.

George G. Crocker, Charles H. Dalton, Thomas J. Gargan, George F. Swain, Horace G. Allen, *Boston Transit Commissioners:*

In the early part of the year ending Aug. 15, 1900, the Charlestown bridge was substantially completed, and on Nov. 27, 1899, it was opened for travel. Since that date the work of the engineering force has consisted chiefly in supervising the removal of the old Charles-river bridge and the construction of the portion of the new fender pier that could not be built until after the old bridge had been removed, and in making the record plans of the Charlestown Bridge as constructed.

## General Description.

The new bridge runs from Keany[1] square in Boston to City square in Charlestown, passing over the Charles river, Water street, and a branch of the Fitchburg railroad. Including the approaches it is about 1,900 feet long. Its width is 100 feet, comprising two sidewalks each 10 feet wide, two carriage ways each 27 feet 9 in. wide in the clear, and a middle space 22 feet wide for electric cars. Over the car space are the elevated tracks of the Boston Elevated Railway Company.

Starting from Keany square the new street rises at the rate of 3 feet per 100 feet to the edge of the river, and continues to rise at the same rate nearly to the southerly draw channel. It passes over the two draw channels on a level grade at a height of 38 feet 6 inches above city base, and then descends at the rate of eight-tenths of a foot per 100 feet to the Charlestown shore, and at the same rate to and across the tracks of the Fitchburg railroad, over which it passes at a height of about 18 feet 3 inches above the tracks, giving a clear passage 16 feet high under the structure. Thence, curving to the right and passing over Water street, it descends at the rate of 3 feet per 100 feet into City square.

The two draw channels for the passage of vessels are each 50 feet wide. The height of the under side of the draw above mean high water is 23 feet. The south draw channel is for vessels passing up or down the river, while the north

[1] By order of the City Council, May 16, 1899, "the open space at the junction of Charlestown, Causeway, and Endicott streets" was named Keany square.

draw channel gives access to the space enclosed by the Warren bridge, the new bridge, the Charlestown shore, and the fender piers of the two draw-bridges.

The main gas-pipe of Massachusetts Pipe Line Company is laid in the space under the floor of the new bridge, between the girders of the fixed spans. It is not attached to the girders, but rests in cradles placed on top of the stone piers. It crosses under the two draw channels and the space between them by a tunnel just east of the bridge.

### PRINCIPAL DIMENSIONS OF CHARLESTOWN BRIDGE.

| | |
|---|---|
| Total length, including approaches | 1,900 feet. |
| Length of Boston approach | 207 " |
| Length of Charlestown approach | 603 " |
| Length of bridge over river | 1,090 " |
| Distance from Boston abutment to draw | 425 " |
| Distance from Charlestown abutment to draw | 425 " |
| Length of draw | 240.5 " |
| Length of fixed spans over river (each) | [1]85 " |
| Width of bridge | 100 " |
| Width of sidewalks (each) | 10 " |
| Width of roadways (each) | 27.75 " |
| Width of car space | 22 " |
| Number of fixed spans over river | 10 |
| Width of draw openings (each) | 50 feet. |
| Height of under side of draw above mean high water | 23 " |
| Weight of draw | 1,200 tons. |
| Width of Water street under bridge | 40 feet. |
| Width of Fitchburg railroad under bridge | 27 feet 6 inches. |
| Width of passageway beside Fitchburg railroad | 25 " 6 " |

### DESCRIPTION IN DETAIL.

#### *River Spans.*

Each of the ten fixed spans over the river consists of six steel plate girders 84 feet 4 inches long and 8 feet 3 inches to 8 feet 9 inches deep. Cross-sections of these spans are shown on Plate 12. Transverse floor-beams, crossing from

[1] Centre to centre of piers.

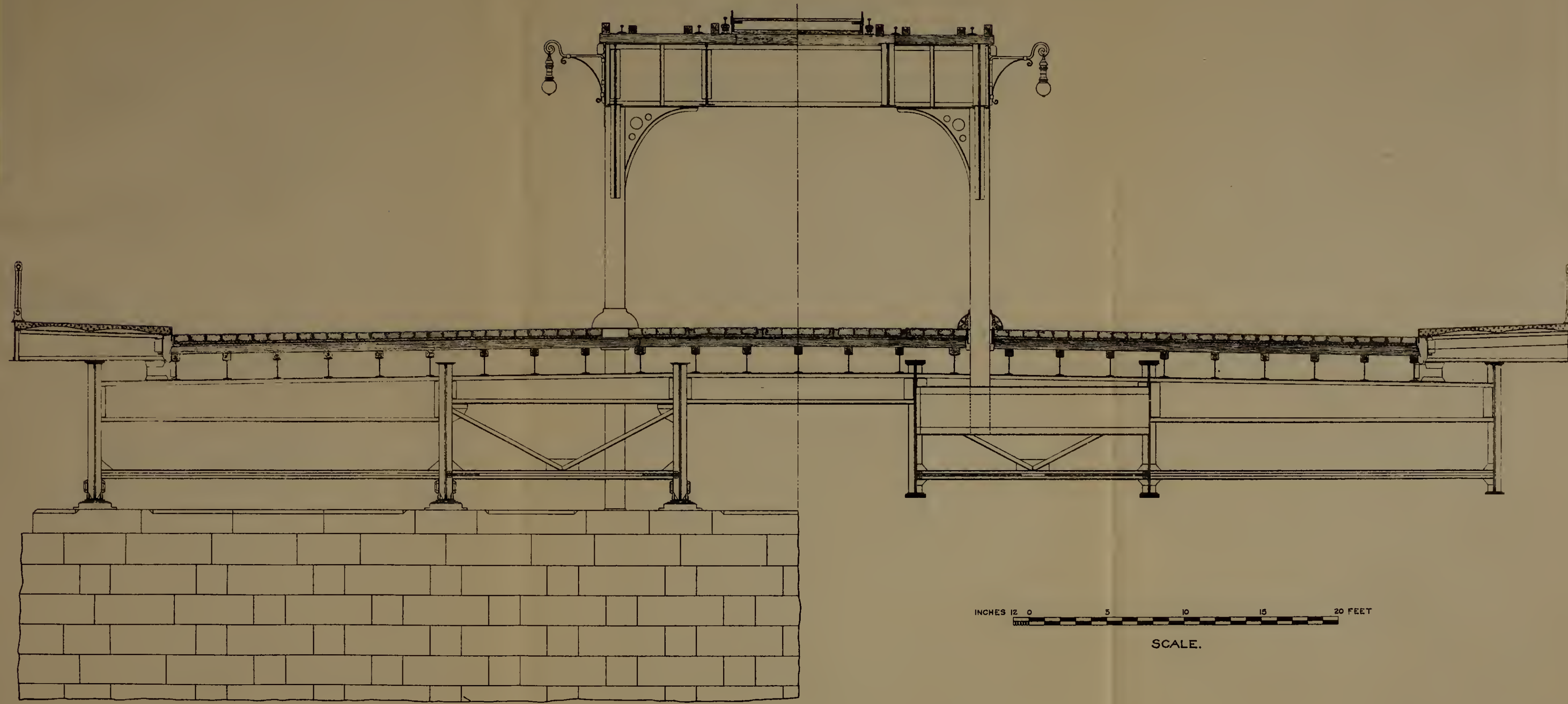
PLATE 10.

CHARLESTOWN BRIDGE FROM BOSTON SIDE OF CHARLES RIVER.

PLATE 11.


CHARLESTOWN BRIDGE FROM CITY SQUARE, CHARLESTOWN.

# ·1896 - CHARLESTOWN BRIDGE - 1899·




HALF CROSS SECTION NEAR PIER.

HALF CROSS SECTION NEAR MIDDLE OF SPAN.

William Jackson
CHIEF ENGINEER.
John E. Cheney
ASST. ENGINEER.

GEO. H. WALKER & CO. BOSTON

DEPOSITING CONCRETE. RIVER PIERS.

girder to girder, support the longitudinal stringers, which are steel I beams. Along the top of each steel stringer is bolted a spiking strip of hard pine, across which the floor planking is laid transversely of the bridge. The floor planking is of hard pine planed to a uniform thickness from 6-inch stock. Each plank is secured to the spiking strips by 10-inch wire spikes, and the planking is coated on top with a preservative compound. On the planking is laid a waterproofing layer consisting of four thicknesses of roofing felt laid in roofing pitch. The rails for the street cars are laid on cast-iron plates resting on the waterproofing, and are spiked to the floor planking. The waterproofing is protected by a 1-inch layer of concrete composed of road-pitch and sand. The wearing surface of the roadway is of granite blocks laid upon a thin bed of sand, with the joints between the blocks filled with pebbles and road pitch.

The sidewalk floor-beams rest directly on the top of the outer girders of the bridge and are anchored to the roadway floor-beams by means of a web. At their outer ends they bear a fascia which gives the outside finish to the edge of the bridge and furnishes support to the outer edge of the sidewalk. At their inner ends they bear a longitudinal channel-iron to which is attached a cast-iron gutter curb. The immediate support of the sidewalk paving is of pressed steel buckle plates riveted at their edges to the floor beams, fascia, and longitudinal channel. The hollows of the buckle plates are levelled up with pitch concrete, upon which is laid a wearing surface of asphalt. At the outer edge of the sidewalk there is a strong and simple iron railing 3 feet $7\frac{1}{4}$ inches high.

The top of the curb is 6 inches higher than the stone paving at the edge of the roadway. Between the curb and the stone paving is a continuous longitudinal slit kept open by separator blocks. This opening is intended to provide for the surface drainage of the roadway and for the difference in expansion between the roadways and the walks. The ends of the floor planks are protected from the drippings by a flashing of sheet copper, and the drippings are diverted from the floor-beams and from the piers and abutments by copper gutters.

Between the flooring planks at the ends of adjacent spans, and at the two abutments, an opening 3 inches wide is left. This space is closed with a copper flashing so corrugated as to allow the opening to change its width as the spans expand and contract with changes of temperature. Over this expansion joint the paving is laid continuously. Expansion between the sidewalks of adjacent spans is provided for by a sliding plate finished on its upper side with a safety tread.

The posts supporting the elevated railway are placed alternately at mid-span, and over the piers of the bridge. Those at the piers stand directly on the masonry; those at mid-span are attached to special cross girders put in by the railway company. In both cases the posts pass through holes left for that purpose in the floor planking. The stone paving is retained in place and prevented from touching the posts by a curb casting having an opening of 18 inches by 26 inches. At the post holes, as at the edges of the roadway, the floor planking is protected from moisture by a copper flashing.

Of the ten fixed spans, all but the two adjacent to the draw are exactly alike, and these two differ only in having an overhang and other details at the ends towards the draw span, and in having provision for the change of gradient of the bridge from the level grade of the draw to the decline towards Boston, and that towards Charlestown.

The main girders of the fixed spans rest in pin-bearing shoes. The shoes at that end of each span towards the middle of the river are bolted to the pier masonry. The shoes at the shoreward end of each span are provided with a roller bearing to allow of expansion and contraction of the girders with changes of temperature.

### *Draw Span.*

The draw span is a swing or turntable draw 240 feet 6 in. long and 100 feet wide between centres of sidewalk railings. It has two sidewalks, two roadways for street traffic, one roadway for surface street cars, and one floor above the latter for a double track line of the Boston Elevated Railway.

The main trusses are four in number, of the pin-connected type, and discontinuous when the draw is in position for travel.

Floorbeams, sidewalk brackets, and beams and stringers of the Elevated Railway floor system are built sections, and roadway and sidewalk stringers are rolled beams provided with nailing pieces of hard pine. The sidewalks are covered with 2-in-thick hard pine plank, and the roadways with 6-in. kyanized spruce, upon which a wearing surface of 2-in.-thick spruce is laid. Plan of draw and section of floor is shown on Plate 17.

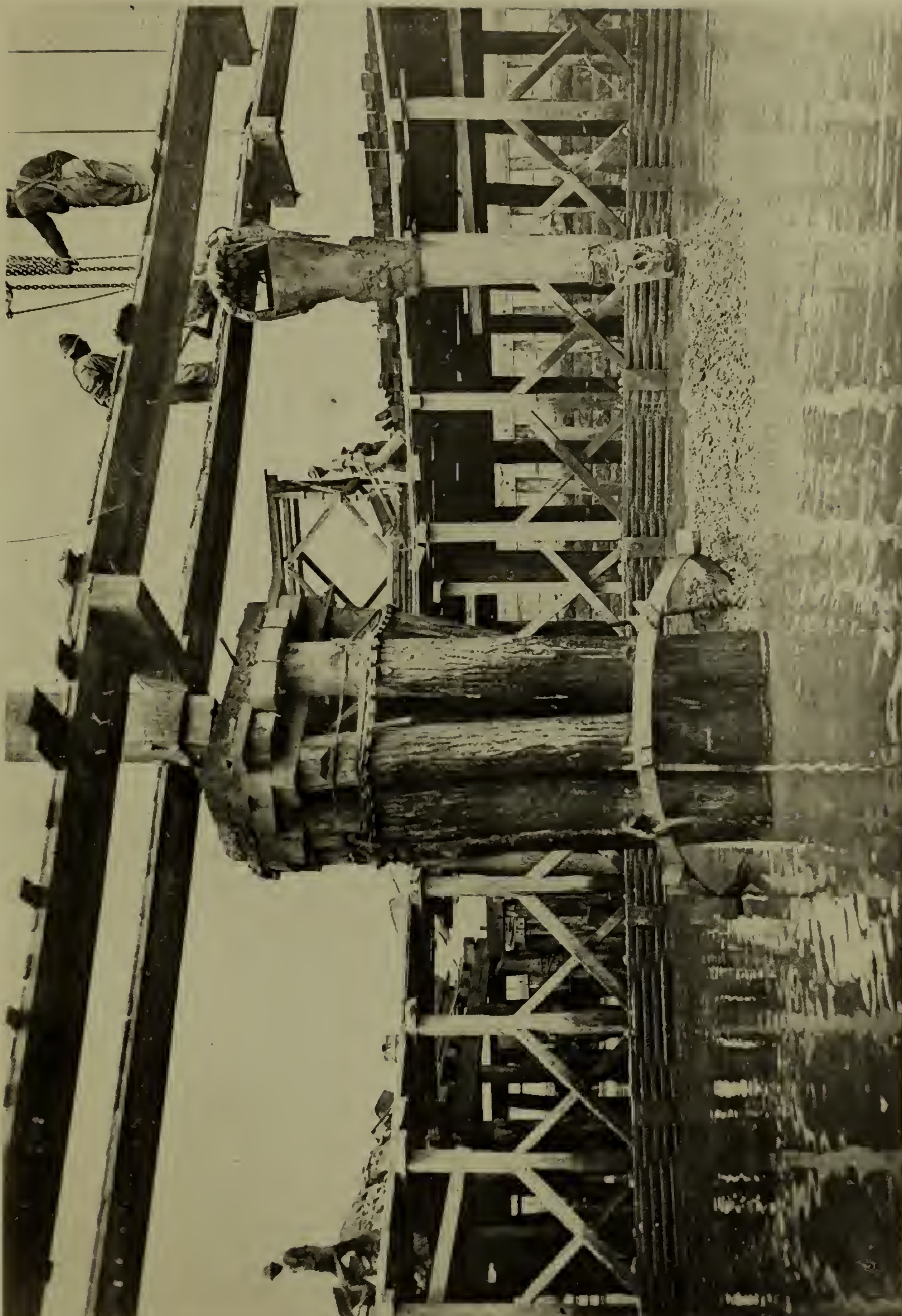
The draw is so designed that when swung clear of its end supports its entire dead load is concentrated on the four tower posts of the inside trusses, the outside trusses being hung to them by two tranverse trusses shown in the section

LAYING TOP COURSE OF CONCRETE IN COFFERDAM.

PLATE 15.

DEPOSITING CONCRETE. DRAW FOUNDATION PIER.

Plate 16.

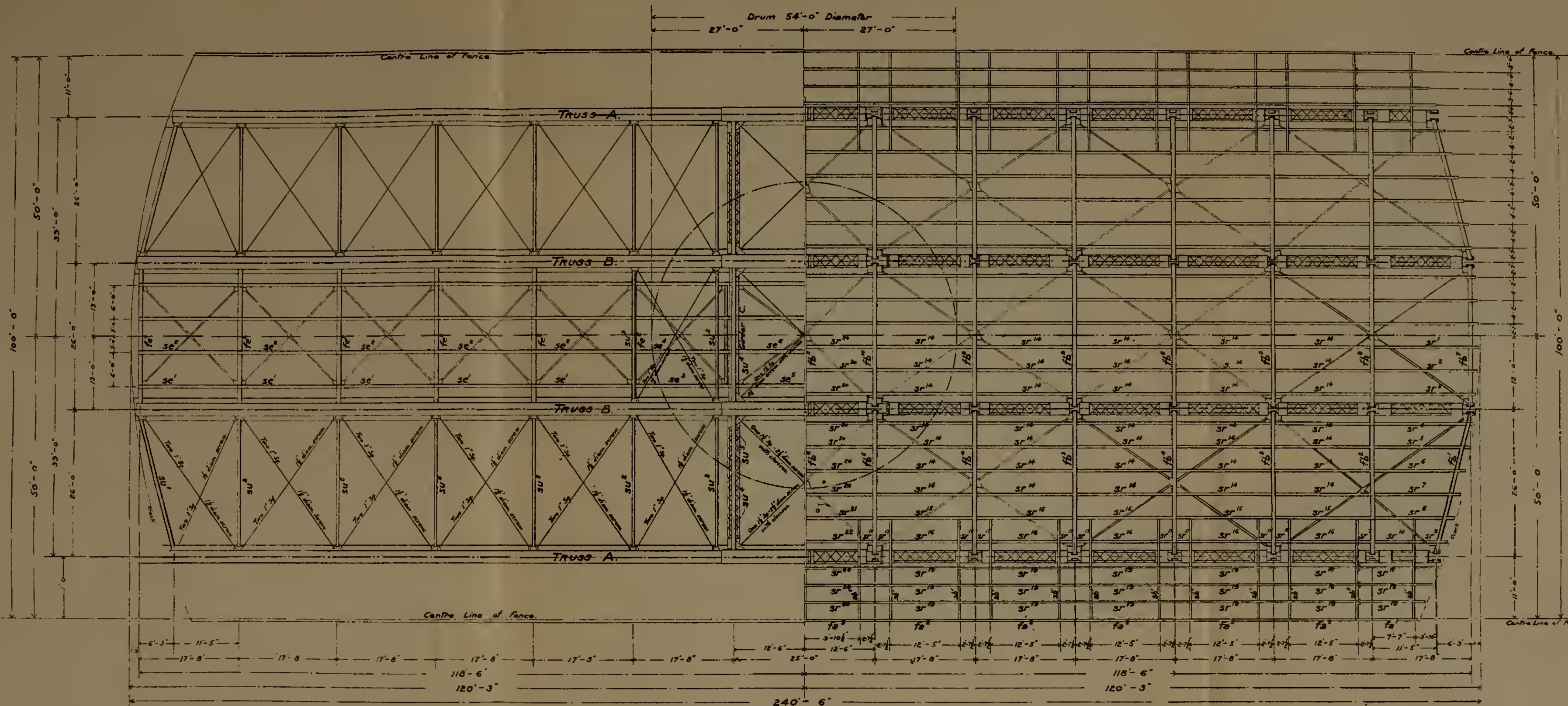


DEPOSITING CONCRETE. DRAW FOUNDATION PIER.

# CITY OF BOSTON – BOSTON TRANSIT COMMISSION – CHARLESTOWN BRIDGE – DRAW SPAN – APRIL 1898.

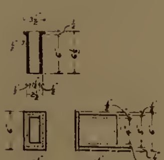
## PLAN AND FLOOR SECTION.

William Jackson
CHIEF ENGINEER.
John E. Cheney
ASST. ENGINEER.

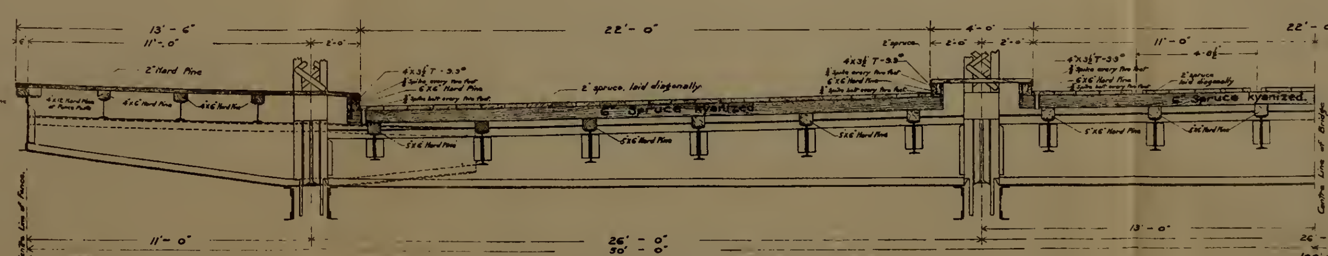



HALF PLAN OF DRAW.

HALF PLAN OF FLOOR SYSTEM.



Cast Iron Scupper.
Forty-four Pieces.




HALF CROSS SECTION OF FLOOR.

**NOTE:**

Nailing pieces to be laid planed side up, and fastened to steel stringers with ⅝ in diam. bolts with flat heads, and cast-iron side-hill washers to fit flanges of beams.

The 6 in roadway plank to be laid planed side up with close joints and fastened with 10 in. steel wire spikes. Two spikes in each end of each piece and one spike at each other bearing.

The 2 in roadway plank to be laid planed side down and well secured to under plank with 30-d iron nails.

Sidewalk plank to be well nailed to stringers with 20-d steel flooring nails, set in ⅛ in. after driving.

GEO. H. WALKER & CO. BOSTON

on Plate 18. The spaces occupied by the middle panels of these trusses being required for the passage of the elevated trains, it was not practicable to counterbrace them, and therefore unbalanced live loads on the outside trusses are transferred to the turntable by cantilever girders to which the trusses were connected by adjustable shoes after the draw was swung. The weight on the four tower posts of the inside trusses is carried to eight equidistant points on the turntable drum by a system of heavy plate girders.

The turntable drum is 54 feet in diameter, with planed steel track, and rests upon seventy steel wheels 27 in. mean diameter.

The lower track is planed steel attached to a bed casting.

The general method of erecting the draw span was that shown on Plate 19.

The turning mechanism of the draw span is shown on Plates 20 and 21, and consists of two trains of gears driven by electric motors and engaging with a circular rack fastened to the bed casting of the lower track. The motors are operated from a controller in the power room. A strap brake operated by compressed air is connected with the main shaft of each train of gears, the purpose of these brakes being to control the draw span in high winds, and retard its motion when necessary. The power of these brakes is such that no damage to the turning mechanism can result from their use. The ends of the draw span are provided with hydraulic jacks for bringing them to the proper grade for traffic. The cylinders of these jacks transfer the weights at ends of trusses to movable landing blocks inserted between them and the draw landings, these blocks being operated by the gateman at each end of the draw span. The draw landings and jacks are shown on Plate 22.

All the operations incident to turning and adjusting the draw span, except the moving of the landing blocks, are controlled from a power room located between four of the distributing girders of the turntable, the plan and section of the power room being shown on Plate 23, and its location on Plate 24. The hydraulic jacks under the ends of the main trusses are operated by a special mineral oil kept under pressure by compressed air in a set of accumulators consisting of heavy steel tubes. The initial air pressure in the accumulators is obtained from an air-compressor of 1,000 pounds per square inch capacity, and the required operating pressure obtained by pumping a proper quantity of oil into them.

An automatic air-pump connected with an air-tank sup-

plies air for operating the air-brakes and an oil ejector. All the machinery in the power room is driven by electric motors, and the room is lighted and heated by electricity. An electric signal system is provided for the general operation of the draw span, and an emergency system, including speaking tubes, affords means of further communication betweeen the operator and the gatemen.

A target is provided to assist the operator in bringing the draw span into the proper position for traffic, this target being electrically illuminated at night.

In operating the draw span, its ends are first lifted clear of the landing blocks and the blocks withdrawn by the gatemen. The pressure on the jacks is then relieved, and the ends of the span allowed to settle to their swinging level, the plungers of the jacks being meanwhile lifted clear of the draw landings by counter-weighted levers. When the draw span returns to its position over the landings, the ends are lifted about one-half inch above the proper grade, and after the landing blocks are inserted, allowed to drop into bearing upon them. In case of air accumulating in the pipes near the jacks, the flow of oil from them is accelerated by the use of an ejector. The time required for the operations just described, and the turning of the draw span through 180 degrees, seldom exceeds four and one-half minutes, the additional delay to traffic on the bridge being ordinarily due to the time taken by the passage of the vessel.

For the 2,701 times the draw span was opened from Nov. 27, 1899, to Aug. 15, 1900, the average delay to traffic per opening was 6 min. 52 sec.; for 312 openings from June 15 to July 15, 1900, 6 min. 15 sec.; and for 344 openings from July 15 to Aug. 15, 1900, 5 min. 58 sec.

From Nov. 27, 1899, to Aug. 15, 1900, 6,033 vessels passed through the bridge, 4,604 of which required the draw span to be opened 2,701 times, and 1,429 passed under it, obviating 1,146 openings of the same.[1]

After an operation of the draw span the air pressure in the accumulators is regained by pumping into them the amount of oil used in the jacks in lifting the ends of the span. Loss of air from the accumulators is replenished from time to time by the air-compressor working in combination with the hydraulic pumps.

---

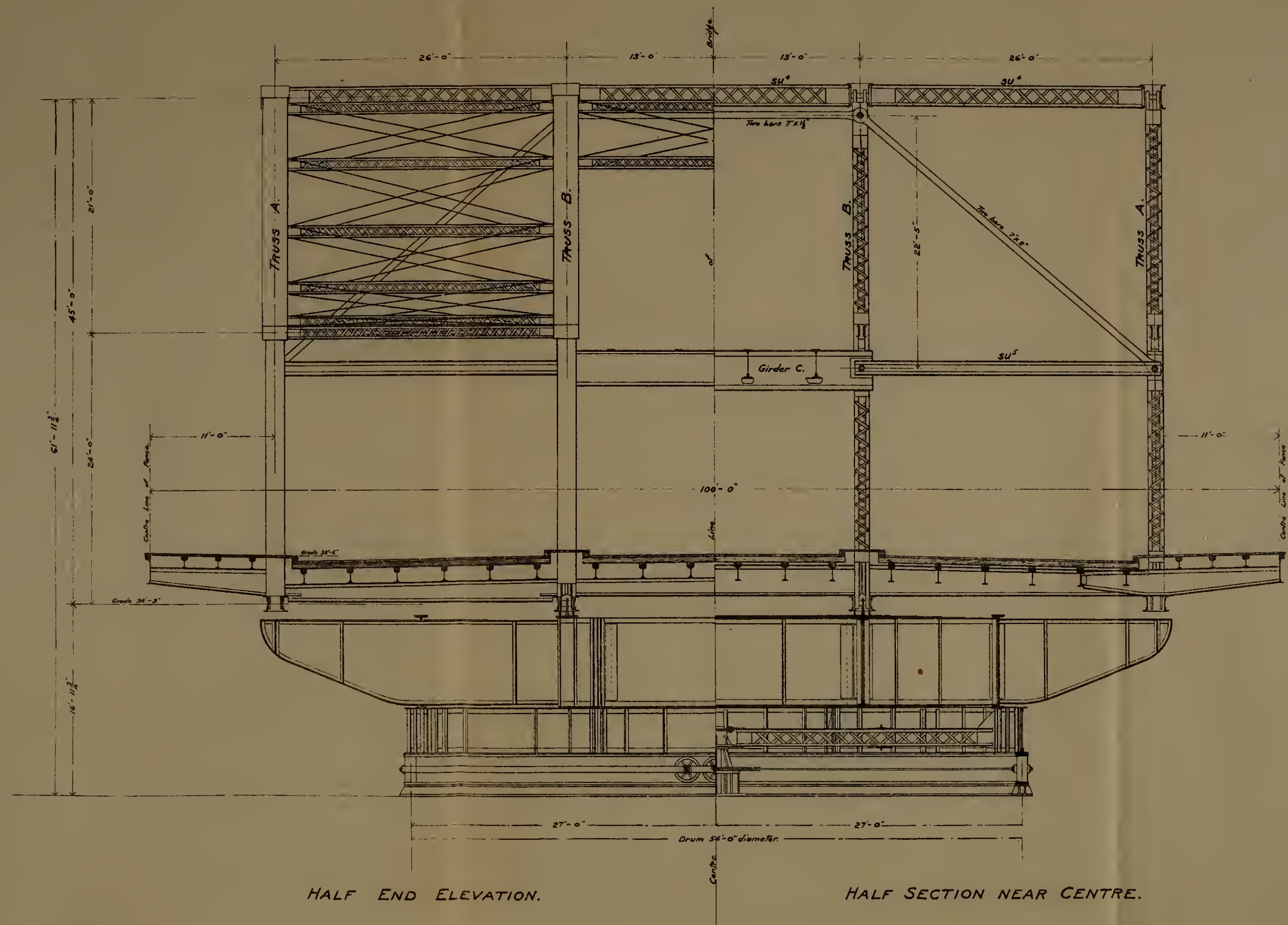
[1] For the year ending Nov. 27, 1900, 8,661 vessels passed through the bridge, the draw span being opened 3,856 times for the passage of 6,533 vessels; 2,128 vessels passed under the draw span, for which 1,691 additional openings would have been made had the bridge been built at the ordinary grade. The average delay to traffic per opening for the year above noted was 6 min. 34 sec., and for the five months ending Dec. 1, 1900, 5 min. 59 sec.

PLATE 18

# CITY OF BOSTON – BOSTON TRANSIT COMMISSION – CHARLESTOWN BRIDGE – DRAW SPAN – APRIL 1898.

## END ELEVATION AND SECTION.

William Jackson
CHIEF ENGINEER.
John E. Cheney
ASST. ENGINEER.




HALF END ELEVATION.

HALF SECTION NEAR CENTRE.

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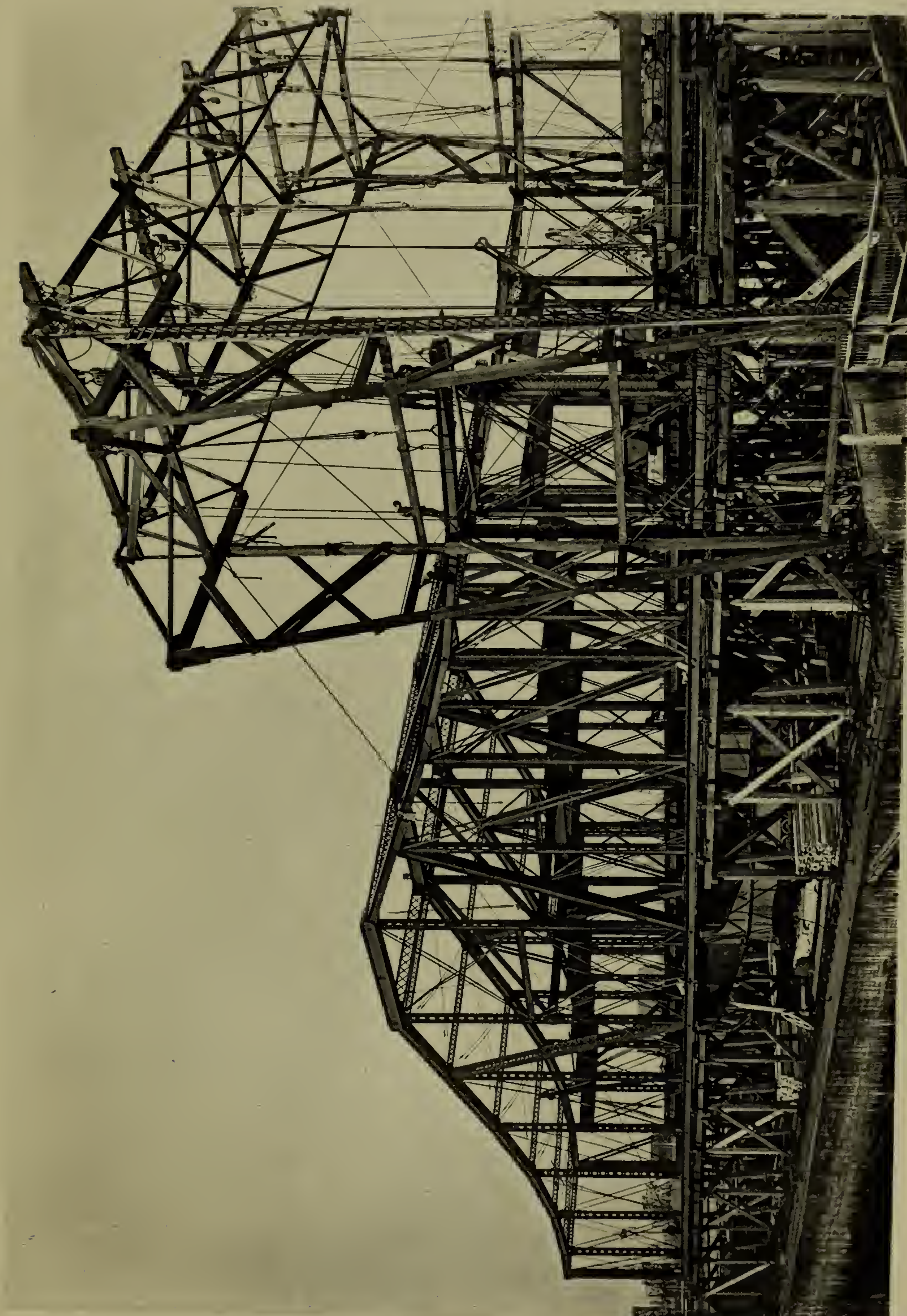
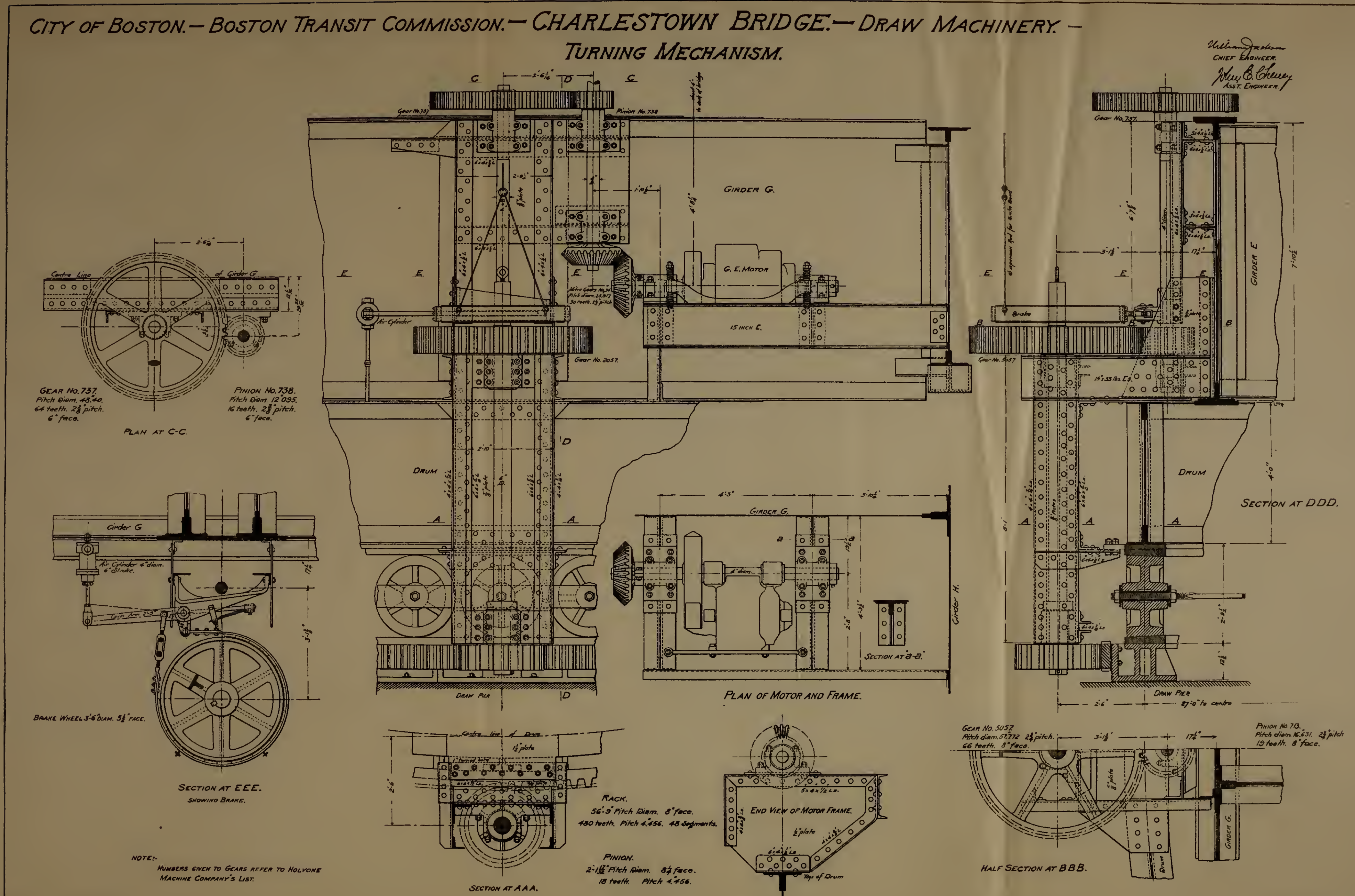
PLATE 19.



METHOD OF ERECTING DRAW SPAN.




GEO. H. WALKER & CO. BOSTON.

### *Painting.*

All steel work in the bridge was painted with one shop coat of red lead. The draw span, railings, and outside faces of the river spans received two coats of a special varnish paint made by Edward Smith & Co., New York, and the balance of the steel work two coats of Durable Metal Coating, made by the same firm.

### *Piers and Abutments.*

The fixed spans rest on ten river piers of granite masonry with concrete foundations, and on two granite abutments which also have concrete foundations. Borings, taken before the work of construction was begun, showed that under the whole width of the river, at varying depths, was a bed of consolidated bowlder-clay, sufficiently hard to furnish a good foundation for the piers and abutments. At the Charlestown abutment, and at the two piers nearest to Charlestown, namely, pier 9 and pier 10, this hard bottom was near the surface, and it was practicable to dredge off all the mud and other soft material with which it was covered, and then to lay the concrete directly on the bowlder-clay. At the other piers and at the Boston abutment the hard bottom was at a greater depth and was covered with a thick layer of softer material, principally a rather soft clay not sufficiently firm to bear safely the weight of piers and bridge. Piles, therefore, were driven through the softer materials till they reached a firm bearing in the bowlder-clay. At piers [1] 2, 3, 4, 5, 6, 7, and 8 all the mud was removed by dredging before the piles were driven. At the Boston abutment and at pier 1 the layer of mud and silt was deep, and only the upper portion was removed.

At piers 6, 7, and 8 the layer of soft clay was absent. The piles were driven easily through loose gravel, sand, and gravel mixed with clay to a depth of from five to fourteen feet, at which depth they encountered material sufficiently firm to support them and the loads to which they would be subjected. At pier 1 the piles had to be driven through a bed of rather soft silt, and then through a deep bed of somewhat firmer material before sufficient resistance was developed.

At pier 4, a few feet below the bottom of the dredged excavation, was found a thin crust or layer of very hard pebbly material underlaid by a deep bed of the soft clay before mentioned. Here it was necessary to drive the piles

[1] The river piers for the fixed spans were numbered consecutively beginning with pier 1 next to the Boston abutment.

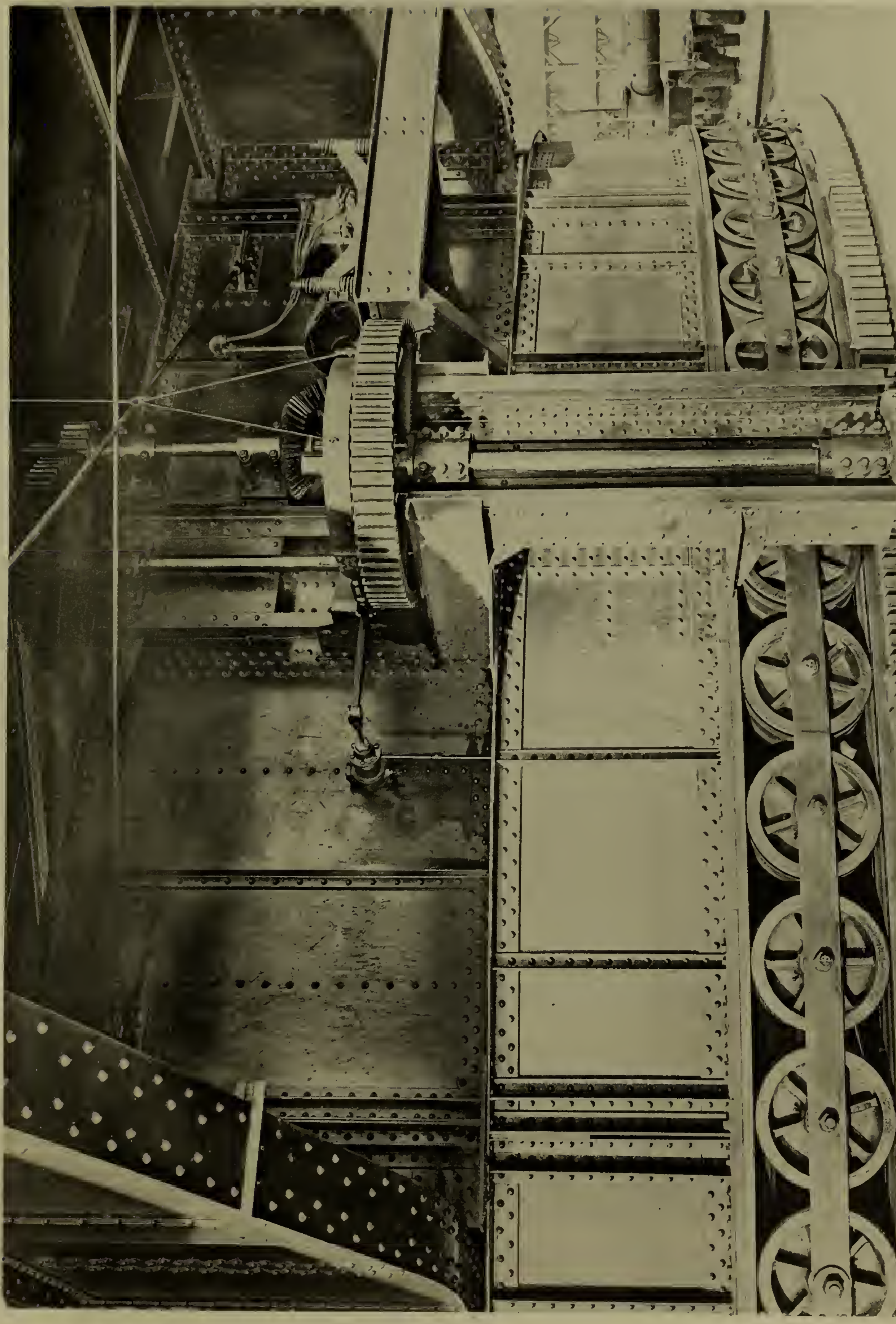
through the crust, and then through the clay until a harder stratum was reached. A few of the piles failed to penetrate the crust.

The formation at pier 3 was similar to that at pier 4, but the crust was thicker and the underlying clay was neither so soft nor so deep. Test piles driven at this pier and at pier 2 when pulled up were found to be crushed and broken at the lower end, owing to the hardness of the crust. Nearly all the piles for these two piers (2 and 3) were therefore shod with iron to protect the lower end. The shoes consisted of a conical casting moulded about a shank of wrought-iron. The shank was driven into an auger-hole bored in the axis of the pile, the foot of the pile having been sawed off square to receive the flat top of the conical casting. Test piles provided with shoes were driven deeply into hard material, and when pulled up were found to be unbroken, with the shoe still attached, but, even when shod, some of the piles in pier 3 could not be driven through the crust. At pier 2 the crust was so hard and thick and the layer of clay so thin and so firm that none of the piles were driven through the hard material.

At pier 5 there was no crust. Above the soft clay was a layer of comparatively loose stony gravel, a great part of which was removed in the dredging. In this pier the piles were driven through the soft clay and into the harder material underneath. Shoes were not required.

The bearing piles in piers 1, 6, 7, and 8, and the Boston abutment were of spruce; at piers 2 and 3, where longer piles were required, Norway pine was used, and at piers 4 and 5, both spruce and Norway pine. The driving of the piles caused the bottom of the excavation to rise a little, so that the bottom of the concrete is somewhat higher than the grade to which the excavation was carried.

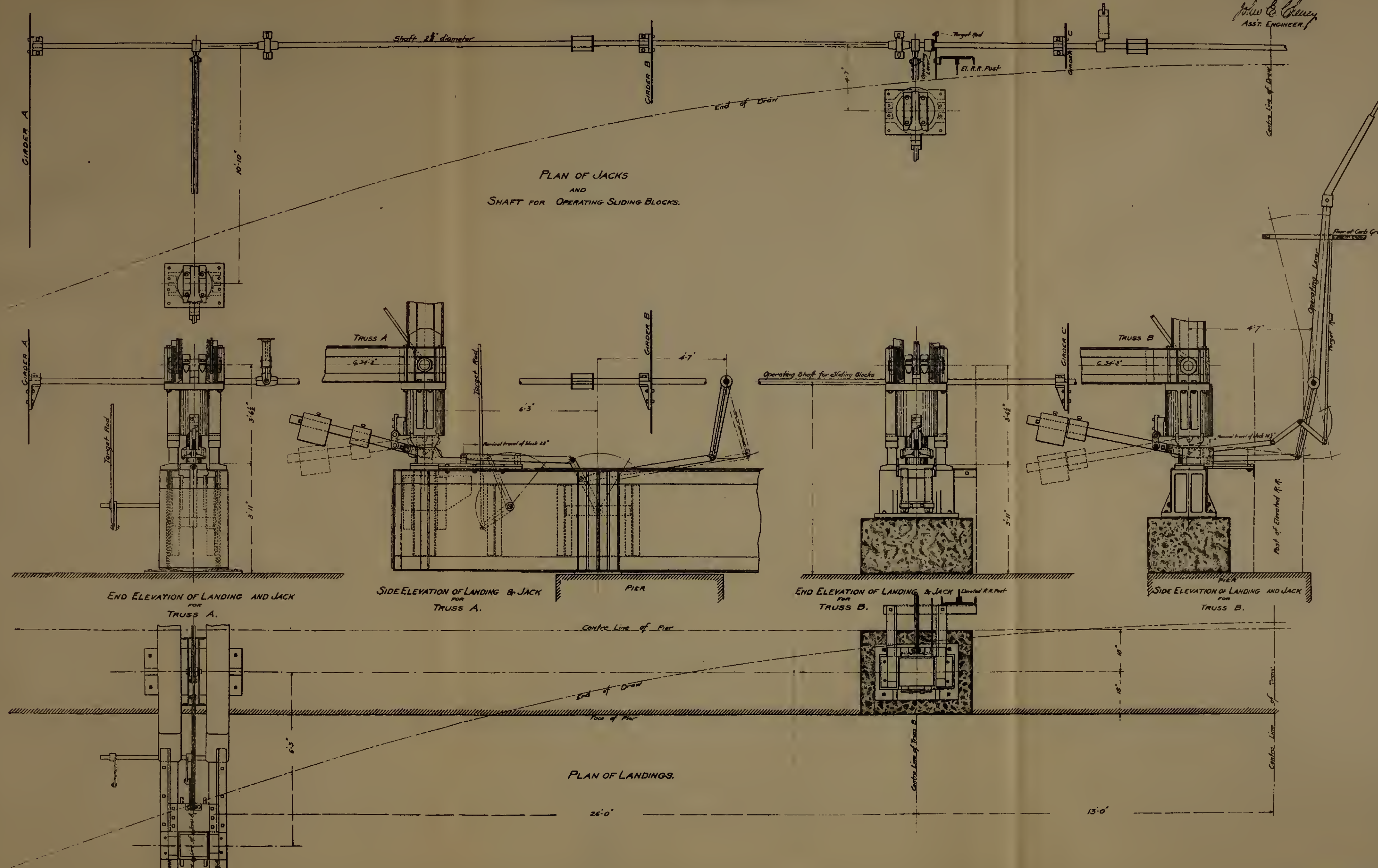
In each pier alternate ranges of bearing piles were cut off at different grades. The contract required the first, third, and fifth ranges, etc., to be cut off about 18 inches above the bottom of the excavation, while the second, fourth, sixth, etc., were to be cut off about ten feet below low water. The latter, or high-grade piles, were not to be cut off until a layer of concrete 6 feet deep had been laid in the bottom of the foundation. The work, therefore, proceeded in the following order: The excavation having been dredged to the depth required by the contract, the low-grade piles were driven, and then cut off at the proper grade with a circular saw. Then the high-grade piles were driven, and were allowed to stand while around them was constructed a coffer-dam of sheet piling to serve as a mould for the concrete foundation.



TURNING MECHANISM. DRAW SPAN.

# CITY OF BOSTON — BOSTON TRANSIT COMMISSION — CHARLESTOWN BRIDGE. — DRAW MACHINERY. — LANDINGS AND JACKS.

William Jackson
CHIEF ENGINEER.
John E. Cheney
ASS'T. ENGINEER.

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Concrete was deposited under water within this coffer-dam by the method to be described; and when a bed of concrete six feet or more in depth had been deposited, the high-grade piles were sawed off ten feet below low water. The concrete laying was then continued under water until the concrete reached a level a little more than one foot below the grade fixed for the bottom of the stone-work.

The contract required that the top foot of the concrete foundation, the part immediately under the stone masonry, should be laid when the coffer-dam was free from water. The coffer-dams, therefore, were pumped out, the top layer of concrete laid by hand to an even grade, and the stone masonry, with its concrete backing, laid on top of it.

This general programme was followed in piers 8, 7, 6, 1, and 2, with no important departure from the construction contemplated in the contract. At pier 3, however, owing to the difficulty of driving the piles through the hard crust before mentioned, many of them were slanted over, so that the piles in one range interlocked with those in another. In this condition of things it would have been practically impossible to lay the concrete, for the crossed piles would have interfered with the movements of the chute or tube through which the concrete was deposited. The contractor was therefore directed to cut off the high piles at a grade a few feet above the level at which the low-grade piles had been cut off, and this plan was followed in piers 4 and 5 also.

The sheet-piling used for the coffer-dams at the piers was the Wakefield triple lap sheet-piling, composed of three thicknesses of two-inch spruce plank bolted and nailed together. For the coffer-dam at the Charlestown abutment, four-inch tongued and grooved spruce plank was used. The sheeting at piers 1, 9, and 10, and at the Charlestown abutment was held in place for driving by double waling attached to piles driven outside the line of the sheeting. At the other piers a frame was built, above water, supported by a curbing attached to certain piles in the outer rows of the foundation that were reserved for the purpose. The posts or vertical members of this frame were Wakefield sheet-piling planks placed at intervals of from six to ten feet. These posts were connected by three lines of double waling bolted to the posts at three different levels. When the framework was completed it was lowered to the bottom so as to enclose the bearing piles. The posts were driven, one by one, into the bottom, the frame having been built with sufficient flexibility to allow this to be done. Then sheet-piling was driven to fill the intervals between the posts, and the frame was bolted to the curbing piles. The curbing

was afterwards used to support the traveller bearing the chute through which the concrete was laid. Clay and stones were dumped into the water around the outside of each coffer-dam to fill up the part of the excavation left outside the sheeting.

At pier 6 the concrete was deposited so rapidly that at one place there was a depth of eight feet of unset concrete in the coffer-dam. The outward pressure of this concrete caused the dam to open at the northeast corner, and a very troublesome leak was the result. At pier 3 the outward thrust of the unset concrete bulged the coffer-dam badly on the north side, and the contractor was allowed to strengthen it against internal pressure by iron rods extending entirely across the dam a little above the level of the concrete already laid, and fastened by nuts on the outside of the sheeting. These rods were placed in position by divers. The coffer-dams at piers 4 and 5 were stayed with similar bolts inserted before the frame was lowered into place.

The concrete was composed of Portland cement, sand, and gravel in the proportion of 1, 2, and 5. For reasons to be explained, a larger proportion of cement was used in some of the piers. The sand and gravel for the concrete were dredged from the harbor near Shirley Gut, and were brought to the work on lighters. The gravel was composed chiefly of rounded pebbles of various sizes. The sand was clean and sharp, composed partly of coarse particles and partly of moderately fine ones. The sand was separated from the gravel by hand screening.

The mixing was done in a continuous mixing machine in which a shaft with paddles revolves in an inclined trough. The sand, gravel, and cement were shovelled continuously into the trough, as nearly as possible in the correct proportions, while a small stream of water, regulated by a valve, ran in at the upper end. The mixed concrete issued from the lower end of the trough, and was carried in wheelbarrows to the place where it was used. This method requires close watchfulness on the part of the inspector, who must see that the proper quantity of cement is shovelled in. The way in which a check was obtained on the proportion of cement is explained later in this report.

The method used for depositing the concrete in the pier foundations (except the upper layer, which the contract required to be deposited when the cofferdam was free from water) was by laying it *en masse* under water through a chute. (See Plate 13.) The tube of the chute was about 14 inches in diameter at the bottom and about 11 inches at the neck, above which was a hopper to receive the

CITY OF BOSTON — BOSTON TRANSIT COMMISSION — CHARLESTOWN BRIDGE — DRAW MACHINERY —
PLAN AND SECTION OF POWER ROOM.

William Jackson
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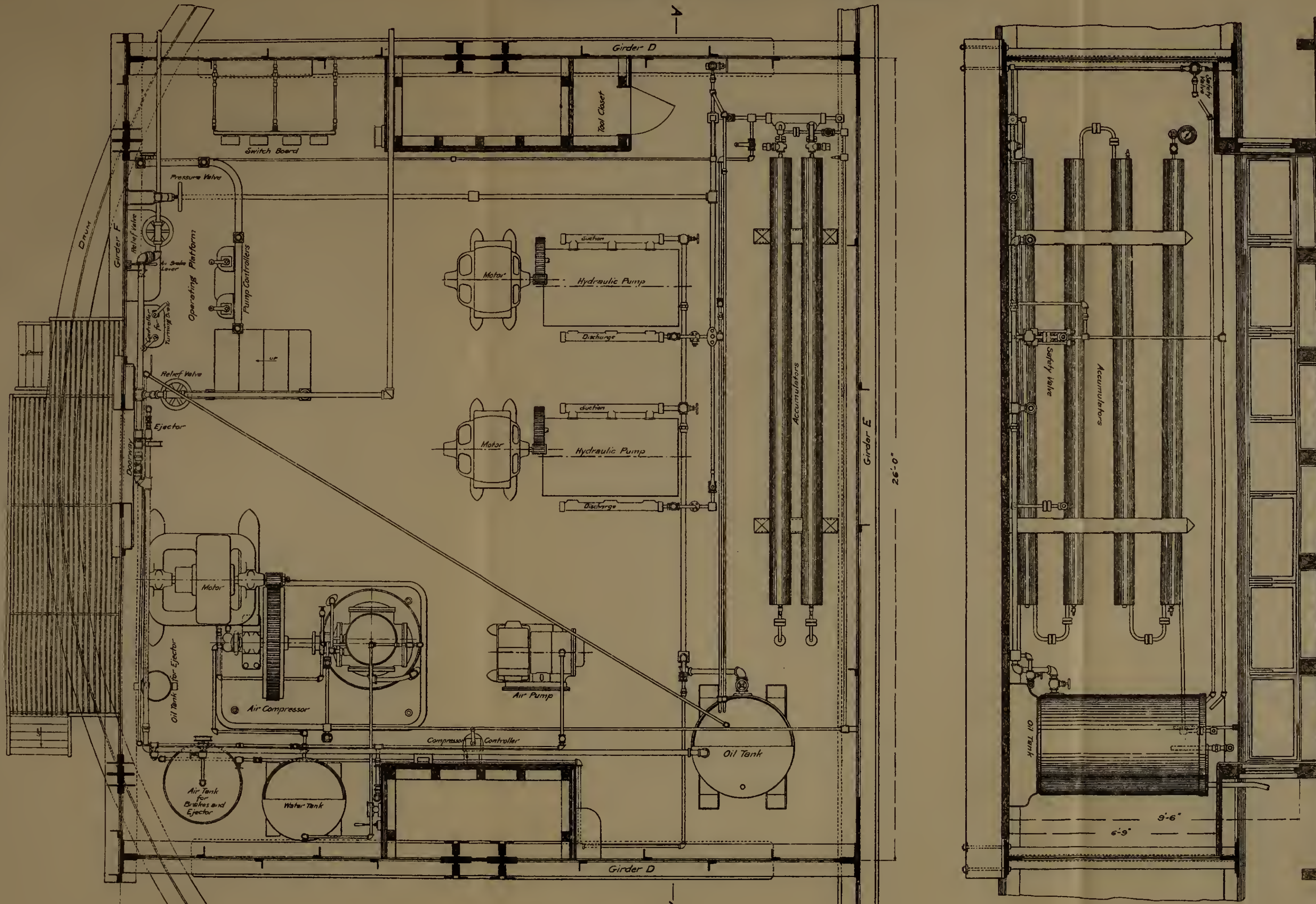
Hugo E. Cheney
ASST. ENGINEER




SECTION AT A-A.

concrete when it was dumped from the wheelbarrows. The tube was made in removable sections bolted together through outside flanges, so that its length could be adapted to the depth of water in which it was to be used. The chute was suspended by a differential hoist from a truck moving on a travelling frame. The frame could be moved on a track from end to end of the coffer-dam, while the truck's motion on the frame was from side to side of the pier, and the hoist gave means for raising or lowering the chute. The method of operation was as follows :

The foot of the tube was allowed to rest on the bottom, and the chute was filled with concrete dumped from wheelbarrows. The chute was then raised slowly from the bottom, allowing a part of the concrete to run out in a conical heap at the foot, while the loss was made good by dumping in more concrete at the top. The truck bearing the chute was then moved from side to side of the dam, so as to leave a ridge or bank of concrete crosswise of the pier, the chute being kept always filled or nearly filled by dumping more concrete into the hopper.

The height of the ridge of concrete was regulated by the height to which the foot of the chute had been raised from the bottom. When the ridge had been completed across the dam the traveller supporting the truck was moved a short distance lengthwise of the pier, and the truck was moved back again across the dam parallel to its former course, allowing the concrete to run out over the edge of the bank first deposited, widening it on the side towards which the traveller had been moved, and this process was continued until the whole area of the foundation was covered with a layer of concrete, upon which, when it was sufficiently hardened, another similar layer or course could be deposited.

The thickness of each course depended upon the height to which the foot of the chute was raised above the top of the preceding course. Courses were laid up to six feet in thickness, but it is thought that the best results were attained with a thickness of two or two and one-half feet.

If the bank is made too high, or if the bottom (or the top of the preceding course) is very uneven, or if the chute is moved along or raised too rapidly, the concrete is likely to flow out so fast as to empty the chute entirely before the flow can be checked. In this event the "charge" is said to be "lost" and the chute must be lowered again to the bottom and refilled. When the charge is lost the water rises inside the chute to the same level as that outside, and into this water the concrete must be dumped until the water is wholly displaced by the concrete.

The contractor was directed whenever the work was resumed after an intermission, or whenever the charge was lost or water leaked into the chute, to throw into it, before each wheelbarrow-load of concrete, until the water was displaced, a quantity of dry cement. He was also directed always to resume work after an intermission with the chute near the centre line of the pier. After the workmen and inspector had gained experience with the chute, the accidental loss of the charge was not a frequent occurrence.

The chute seems to work best when the concrete is mixed not quite moist enough to be plastic. If it is mixed too wet the charge is likely to be lost; if very dry there is a tendency to choking of the chute. The working of the chute is affected also by variations in the proportions of sand and gravel. With gravel in excess the outside water too readily forces its way in at the bottom. With an excess of sand the concrete tends to clog in the chute. A difficulty sometimes met with is that when a sudden rush of concrete takes place, even if the charge is not entirely lost the concrete within the chute often falls far below the level of the water outside. The outside water then, especially if there is a deficiency of sand in the concrete, is likely to force its way through the concrete remaining in the bottom of the chute, tending to separate the cement from the sand and gravel, making the concrete too wet and threatening a complete loss of charge.

In piers 3, 4, and 5, where the contractor was directed to cut off the high-grade piles at a level only a few feet higher than that at which the low-grade piles had been cut off, provision was made for binding the concrete together both longitudinally and transversely by second-hand iron rods imbedded in the mass. When not already provided with heads or nuts, they were heated and bent over at the ends to give them a better hold on the concrete. On top of each layer of concrete these rods were deposited, on one layer crosswise and on the next layer lengthwise of the pier. The transverse rods were spaced sometimes 5 feet and sometimes $3\frac{1}{2}$ feet apart. Two lines of longitudinal rods were laid, one line near each side of the pier, the rods overlapping a foot or two at the ends.

As the concrete foundations are to be exposed to the action of salt water, especially after the sheeting shall have disappeared, it was thought prudent to obtain some information as to the occasional disintegration of Portland cement concrete by sea water. It was found that though there are several opinions as to the cause of such failures, and more than one theory as to the chemical action involved, yet the best authorities agree in the opinion that if the concrete is

# CITY OF BOSTON — BOSTON TRANSIT COMMISSION — CHARLESTOWN BRIDGE — DRAW MACHINERY. —
## GENERAL PLAN OF MACHINERY AND PIPING.

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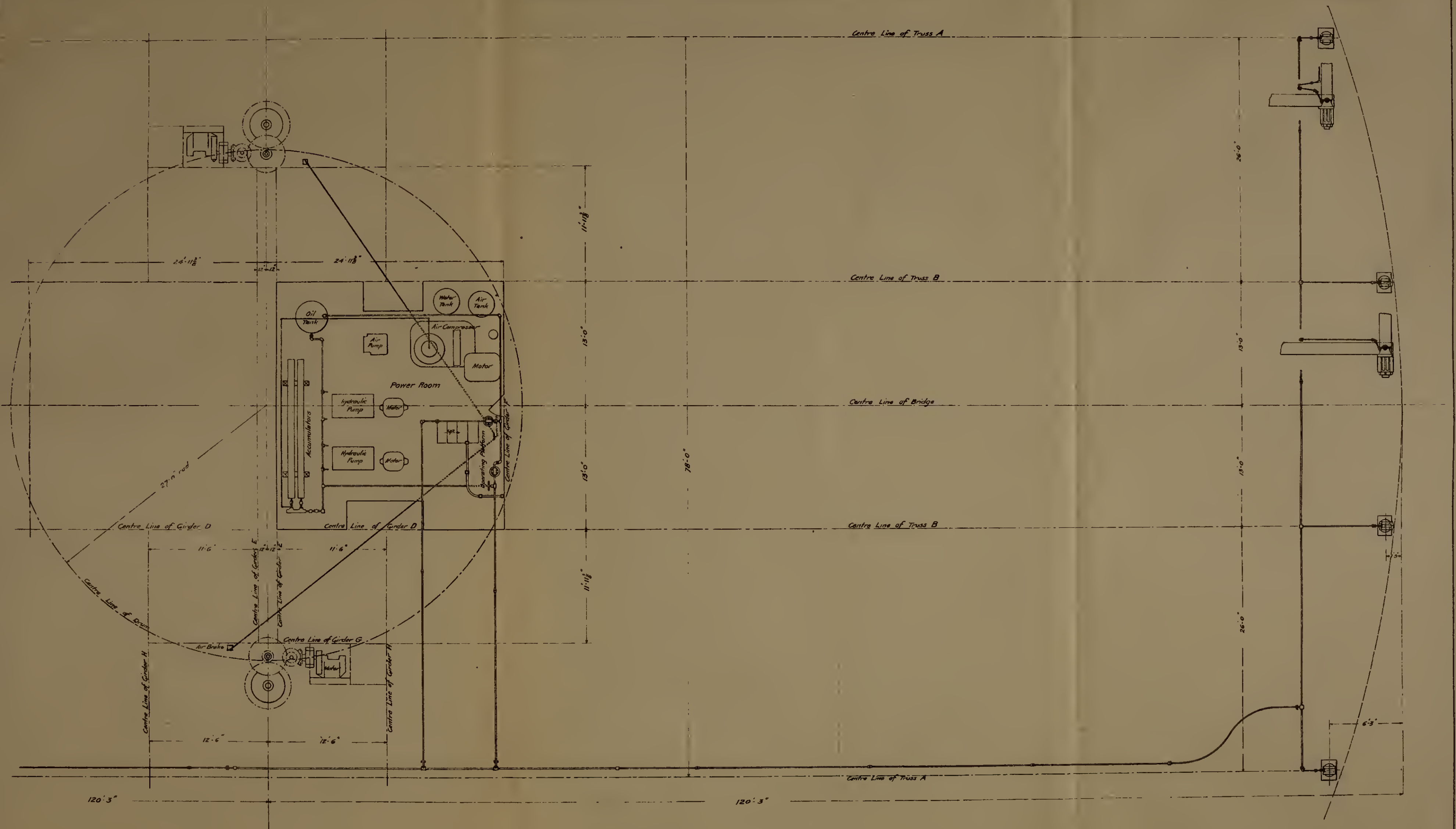
John E. Cheney
ASST. ENGINEER.



made from a cement of normal composition, mixed with sand and gravel in such proportions as to make a nearly impervious mass, and especially if the concrete is not exposed to any unbalanced water pressure that would tend to cause a current through the mass, there is no danger of failure.

As the concrete foundations of the Charlestown bridge (except that of the draw-pier) are wholly submerged even at low tide, and are not exposed to any unbalanced water pressure, there is no tendency to the formation of currents through the concrete. But the method of measuring and mixing the materials was such that some variation in the proportions was inevitable, and so, to assure fairly impervious work, the contractor was directed to use such excess of cement above the proportions called for by the contract as to assure at least the proper richness in all parts of the work. The proportion of cement actually used in each part of the work was ascertained by keeping an account of the number of barrels of cement used in each layer of concrete. Soundings were taken before and after each layer was deposited, and from these soundings the number of cubic feet of concrete in each layer was computed.

In order that cements of abnormal composition might be rejected, it was deemed prudent, in addition to the usual physical tests, to make a chemical analysis of a sample from each lot of cement furnished to the contractor. The analyses are recorded in the following table. Lots 4 to 18 inclusive were analyzed by Dr. Arthur A. Noyes, lots 22 and 23 by Albert Sauveur, and the remainder by Henry J. Williams. The table includes analyses of cement offered for the draw-pier and the submarine portion of the Charlestown approach, as well as for the ten piers and the abutments. Cement intended for work above water was not generally analyzed.

## CEMENT ANALYSIS, CHARLESTOWN BRIDGE.

| Lot. | Sample number. | Per cent. of moisture in original sample. | Per cent. of $CO_2$ in original sample. | Other volatile matter (per cent. of original sample.) | Per cent. of Ignited Sample. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lime. Ca O | Silicia. Si $O_2$ | Alumina. $Al_2O_3$ | Sesquioxide of iron. $Fe_2O_3$ | Magnesia. Mg O | Sulphuric acid. $SO_3$ | Undetermined. | Alumina and iron oxide. $Al_2O_3 + Fe_2O_3$ | |
| 4 | 1 | 0.95 | 0.85 | ..... | 62.35 | 22.75 | 8.15 | 2.60 | 1.10 | 1.45 | 1.60 | 10.75 | |
| 5 | 2 | ..... | ..... | .... | 60.80 | ........ | ........ | ........ | ...... | 1.25 | ..... | ........ | |
| 6 | 5 | ..... | ..... | .... | 58.75 | 20.25 | ........ | ........ | ...... | 1.40 | ..... | 15.35 | |
| 7 | 6 | ..... | ..... | ..... | 60.65 | 23.20 | ........ | ........ | ...... | 1.40 | ..... | 11.55 | |
| 8 | 7 | 0.70 | 0.45 | ..... | 59.90 | 24.00 | 8.60 | 3.15 | 1.20 | 1.50 | 1.65 | 11.75 | |
| 9 | 9 | ..... | ..... | ..... | 61.80 | 24.10 | ........ | ........ | ...... | 1.50 | ..... | 12.05 | |
| 10 | 10 | ..... | ..... | ..... | 64.10 | 22.30 | ........ | ........ | ...... | 1.45 | ..... | 11.30 | |
| 11 | 12 | 1.65 | 0.50 | ..... | 60.35 | 24.05 | 9.00 | 3.40 | 1.20 | 1.95 | 0.05 | 12.40 | |
| 12 | 13 | 1.75 | 0.35 | ..... | 63.75 | 22.45 | 8.40 | 2.90 | 0.95 | 1.65 | ..... | 11.35 | |
| 13 | 14 | 0.20 | 0.35 | ..... | 61.05 | 23.30 | 8.80 | 2.80 | 1.10 | 1.50 | 1.45 | 11.60 | |
| 14 | 15 | 0.55 | 0.20 | ..... | 60.65 | 23.60 | 8.60 | 2.85 | 1.15 | 1.55 | 1.55 | 11.50 | |
| 15 | 16 | 0.90 | 0.35 | ..... | 62.60 | 22.70 | 8.15 | 2.95 | 1.15 | 1.20 | 1.25 | 11.10 | |
| 16 | 17 | 0.50 | 0.45 | ..... | 62.00 | 22.55 | 8.70 | 2.70 | 0.70 | 1.85 | 1.50 | 11.40 | |
| 17 | 18 | 0.70 | 0.35 | ..... | 62.90 | 22.20 | 7.65 | 2.90 | 1.05 | 1.50 | 1.75 | 10.55 | |
| 18 | 19 | 0.60 | 0.35 | ..... | 61.55 | 23.00 | 8.65 | 3.15 | 0.90 | 1.65 | 1.15 | 11.75 | |
| 19 | 21 | .... | 0.16 | 0.68 | 62.09 | 23.44 | 7.16 | 3.51 | 0.96 | 1.92 | 0.92 | 10.67 | |
| 20 | 22 | 0.09 | 0.49 | 1.27 | 56.74 | 26.24 | 7.53 | 3.56 | 1.19 | 2.40 | 2.34 | 11.09 | rejected |
| 21 | 23 | 0.16 | 1.47 | 0.14 | 60.28 | 22.96 | 8.21 | 3.94 | 0.89 | 1.22 | 2.50 | 12.15 | |
| 22 | 24 | ..... | 1.36 | 0.03 | 59.30 | 23.00 | 7.95 | 4.43 | 0.98 | 1.90 | 2.43 | 12.38 | |
| 23 | 25 | 0.03 | 1.34 | 0.02 | 60.40 | 22.32 | 8.65 | 3.64 | 1.10 | 1.69 | 2.20 | 12.29 | |
| 24 | 26 | 0.03 | 0.80 | 1.40 | 59.33 | 24.76 | 8.87 | 3.28 | 1.20 | 0.34 | 2.22 | 12.15 | |
| 25 | 27 | 0.20 | 0.37 | 1.16 | 60.40 | 24.47 | 7.52 | 3.56 | 1.39 | 2.07 | 0.59 | 11.08 | |
| 26 | 28 | ..... | 0.22 | 0.94 | 60.58 | 23.81 | 9.40 | 1.91 | 1.50 | 1.80 | 1.00 | 11.31 | |
| 27 | 30 | 0.06 | 0.33 | 0.93 | 60.64 | 23.61 | 7.88 | 3.47 | 1.30 | 2.30 | 0.80 | 11.35 | not used |
| 28 | 31 | 0.06 | 0.26 | 0.42 | 60.10 | 24.72 | 7.71 | 3.66 | 1.52 | 2.02 | 0.27 | 11.37 | not used |
| 29 | 35 | 0.05 | 0.44 | 0.20 | 61.00 | 23.73 | 7.57 | 3.82 | 1.24 | 1.69 | 0.95 | 11.39 | rejected |

PLATE 25.

CHARLESTOWN BRIDGE AND OLD CHARLES RIVER BRIDGE.

| Lot. | Sample number. | Per cent. of moisture in original sample. | Per cent. of $CO_2$ in original sample. | Other volatile matter (per cent. of original sample). | PER CENT. OF IGNITED SAMPLE. Lime. $CaO$ | Silica. $SiO_2$ | Alumina. $Al_2O_3$ | Sesquioxide of iron. $Fe_2O_3$ | Magnesia. $MgO$ | Sulphuric acid. $SO_3$ | Undetermined. | Alumina and iron oxide. $Al_2O_3 + Fe_2O_3$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | .. | 0.63 | 0.65 | 0.35 | 62.60 | 22.36 | 7.36 | 2.52 | 2.17 | 2.15 | 0.84 | 9.88 | rejected |
| B | 33 | 0.12 | 0.40 | 0.73 | 62.76 | 21.38 | 7.14 | 3.99 | 2.29 | 1.47 | 0.97 | 11.13 | not used |
| C | 34 | 0.10 | 0.46 | 0.60 | 61.28 | 23.85 | 6.23 | 2.80 | 3.75 | 1.27 | 0.82 | 9.03 | not used |
| D | 36 | 0.02 | 15.20 | 1.93 | 70.18 | 17.88 | 5.78 | 2.28 | 2.04 | 1.22 | 0.62 | 8.06 | rejected |
| F | 37 | 0.28 | 0.53 | 1.16 | 60.53 | 23.24 | 7.39 | 3.12 | 3.51 | 1.52 | 0.69 | 10.51 | |
| G | 38 | 0.16 | 0.42 | 1.67 | 60.34 | 23.80 | 7.39 | 2.99 | 3.48 | 1.41 | 0.59 | 10.38 | |
| H | 39 | 0.31 | 0.26 | 1.05 | 60.26 | 23.16 | 8.21 | 2.52 | 3.40 | 1.44 | 1.01 | 10.73 | rejected |
| I | 40 | 0.19 | 0.16 | 1.44 | 60.42 | 23.06 | 7.37 | 2.07 | 4.31 | 1.55 | 1.22 | 9.44 | rejected |
| L | 41 | 0.27 | 0.34 | 1.53 | 59.46 | 23.74 | 6.62 | 2.53 | 4.55 | 1.44 | 1.66 | 9.15 | |
| M | 42 | 0.42 | 0.10 | 1.71 | 61.14 | 23.22 | 8.66 | 2.38 | 2.39 | 1.51 | 0.70 | 11.04 | |
| N | 43 | 0.13 | 0.21 | 1.43 | 60.32 | 23.22 | 7.59 | 2.77 | 3.54 | 1.56 | 1.00 | 10.36 | |
| O | 44 | 0.15 | 0.22 | 1.50 | 60.90 | 23.36 | 7.34 | 2.87 | 2.92 | 1.68 | 0.93 | 10.21 | |
| P | 45 | 0.33 | 0.24 | 2.32 | 61.40 | 23.11 | 6.74 | 2.69 | 3.71 | 1.83 | 0.52 | 9.43 | |
| P | 46 | 0.24 | 0.36 | 1.97 | 61.39 | 23.71 | 6.52 | 2.69 | 3.64 | 1.57 | 0.48 | 9.21 | |
| Q | 47 | 0.05 | 0.35 | 0.42 | 62.88 | 22.08 | 7.54 | 3.09 | 1.60 | 2.16 | 0.65 | 10.63 | rejected |
| R | 48 | 0.18 | 0.47 | 1.22 | 59.98 | 23.71 | 7.06 | 2.74 | 4.26 | 1.57 | 0.68 | 9.80 | |
| S | 49 | 0.39 | 0.31 | 1.45 | 61.14 | 23.46 | 6.30 | 2.83 | 4.42 | 1.30 | 0.55 | 9.13 | |
| T | 50 | 0.12 | 0.32 | 1.49 | 61.49 | 22.81 | 6.22 | 2.53 | 3.69 | 1.46 | 1.80 | 8.75 | |
| U | 52 | 0.64 | 0.65 | 0.56 | 61.92 | 23.19 | 7.65 | 2.29 | 3.28 | 1.47 | 0.20 | 9.94 | |

The contract required that the top layer of each concrete foundation should be laid when the coffer-dam was free from water. When the coffer-dams were pumped out it was found that the leakage through the sheeting was considerable. At almost every pier a strong current of water was always running towards the pump-well at one end of the dam, and for this current channels had to be provided. At first the water was allowed to run in side-channels along the sheeting, but the coffer-dam at pier 6 leaked so badly that the side channels alone would not have been sufficient to convey the leakage to the pump. The contractor at his own suggestion was therefore directed to leave another channel along the middle of the pier, to be filled with concrete after the first

course of stone should be laid. This plan worked so well that it was followed in the other piers. See Plate 14.

Before the top layer of concrete was deposited, anchor bolts $3\frac{1}{2}$ feet long were screwed 5 inches into the sheeting (from the inside) at a level 8 inches below the grade of the top of the concrete, so as to be imbedded in that concrete when it should be laid. They were intended to hold the sheeting flanks screwed in place after the completion of the work, but they serve also to bind the concrete which fills the side channels firmly to the main body of the foundation.

The concrete that was laid after the coffer-dams were pumped out worked best when mixed wet enough to be slightly plastic. If mixed too dry it was apt to be washed and undercut by the water flowing in the channels. If too wet it could not be rammed properly and was unsatisfactory for obvious reasons, but when given the right consistency it would oppose a considerable resistance to even a rather strong current of water.

The top layer of concrete set and hardened quickly, and, except in pier 8, where it was laid when the temperature of the salt water was below 32° F., it was strong enough to receive stone-work 24 hours after it was laid.

The top of the concrete foundation (and bottom of the stone masonry) in all the piers except 1, 9, and 10 is 5 feet $4\frac{5}{8}$ inches below mean low water. At piers 1, 9, and 10 it is at a somewhat higher grade. The stone piers are of large blocks of quarry-faced granite backed with Portland cement concrete. The piers are pointed at the ends and have a curved profile. A coping course projects 6 inches beyond the face of the pier, and on the top of the coping is the bridge-seat of granite. The first four courses of stone-work were generally laid when the coffer-dam was pumped out. Then generally the pump was removed for use elsewhere, and the masonry was continued by tide work until it reached high water level. The sheeting and piles of the coffer-dam were sawed off a few inches above the top of the concrete foundation.

The abutments are of masonry similar in quality to that of the piers, but they have a straight batter instead of a curved profile. The coping of each abutment is surmounted by a parapet wall. That on the Boston abutment serves as a retaining wall for the earth embankment of the Boston approach, and is pierced for the pipes of the Massachusetts Pipe Line Company. The parapet on the Charlestown abutment forms the end wall of the storage building under the Charlestown approach. Both parapet walls have recesses

PLATE 26.

PORTION OF OLD CHARLES RIVER BRIDGE.

for the elevated railway posts which stand directly on the coping course of the abutments.

In constructing the circular foundation pier for the draw span, the bottom of the river was dredged to a level surface about 27 feet below mean low water, and 967 spruce piles were driven within a circular space about 75 feet in diameter. The piles were sawed off from 2 to 4 feet above the dredged bottom. The wooden curb which served to retain the concrete forming the main portion of the pier is of somewhat novel construction. It is approximately cylindrical, 72 feet mean diameter and 32 feet high. It is built of 3-inch by 12-inch spruce planks laid flatwise, there being 24 planks about 10 feet long in each course. The planks were planed on one side to an even thickness, sawed to proper length and end bevel, and spiked and tree-nailed together. Vertical timbers of hard pine were placed about 10 feet apart inside the curbing, and bolted to it as the laying of the planks proceeded.

The curbing was built floating in the water and kept in position by temporary radial arms attached to a ring placed about a central clump of piles. As the building up of the curbing progressed, it was weighted by means of temporary pockets on the inside filled with concrete, and it was finally sunk to the proper grade by outside pockets filled with gravel. This curbing was filled with Portland cement concrete laid under water by the same method adopted for the foundations of the other piers. (See Plates 15 and 16.) From a level 3 feet above mean low water the draw-pier has the form of a truncated cone. It is of concrete laid inside a wooden form which has been left in place. At its top is a granite coping ring bearing the lower track of the draw turn-table.

In this pier the concrete for several feet above low water was deposited through a chute, and observations were made upon the action of the concrete as it emerged from the tube both above and below water. A fair sample of its appearance under both conditions is to be seen on Plate 16. When the bottom of the tube was at or below the surface of the water, the movement of the concrete in taking its natural slope did not discolor the water, this showing that in the ordinary use of the chute, little or no cement is likely to be washed from the sand and stone as the concrete emerges from the tube. The casting to be seen at the bottom of the tube was used temporarily as a counterweight to keep the tube plumb.

In the early part of November, 1898, an attempt was made to bore a hole from top to bottom of this pier by means of a

diamond drill, to ascertain the quality of the concrete. Owing to the small diameter of the drill, 3 inches, and the difficulty and expense of operating it in concrete containing smooth, hard pebbles, the hole was bored but 19 feet 9 inches deep. The experiment, however, showed the concrete bored into to be in a satisfactory condition, that deposited below water being at least equal in quality to that laid in the upper part of the pier by the ordinary methods.

Levels taken on this pier, before, during, and after the erection of the draw span, showed that no settlement had taken place since its completion.

The fender pier for the draw span and its foundation, and the fenders adjacent to piers 5 and 6, are of hard-pine timber supported by oak piles. A house for the accommodation of the draw tenders is located on the fender pier.

### *Boston Approach.*

The Boston approach rises on a 3 per cent. gradient from Keany square to the edge of the river. It consists of a solid earth embankment, retained at the sides by masonry retaining walls. The east wall, which is founded on an ancient earth wharf, is of rubble laid in cement on a base of natural cement concrete. Its maximum height is about 13½ feet. The west wall is located partly on one of the old wharves and partly in the slip between two of the wharves. The portion on the wharf is of rubble masonry. The portion in the slip is of dressed granite, quarry faced, in courses of thickness uniform with the courses of the abutment. The foundation is of Portland cement concrete on piles. The maximum height of this wall is about 24 feet above the concrete base. To diminish the outward thrust of the embankment on the abutment and on the high portion of the west wall, the filling adjacent to these walls is sustained by a timber platform about 8 feet above mean low water. This platform rests on piles.

The paving of the Boston approach is of granite blocks on a gravel base. The sidewalks are of brick. On the top of the west wall is an iron fence like that on the river spans.

### *Charlestown Approach.*

From City square to Water street the Charlestown approach rises on a 3 per cent. gradient. This part of the approach is a solid earth embankment, retained, on its western side, that towards Warren avenue, by a wall of dressed granite. A granite staircase leads up from Warren avenue at the

PLATE 27.

PORTION OF OLD CHARLES RIVER BRIDGE.

corner of Water street. The retaining wall is surmounted by a granite balustrade. There is no retaining wall on the east side of the embankment; the filling is allowed to slope on to land acquired by the commission. It is proposed to build an iron staircase from Water street on this side. The roadway paving between City square and Water street is of granite blocks on gravel.

Water street is crossed by a bridge of two spans, made of steel I beams, between which are built brick arches levelled up with cement concrete, upon which is laid a waterproofing layer of roofing felt and pitch protected with a one-inch layer of pitch concrete. The paving is of granite blocks with pitched joints. The central pier is a trestle-bent of steel upon a heavy granite foundation designed to serve as a wheel guard. The abutments on both sides of Water street are of quarry-faced granite in 2-foot courses, backed with rubble and laid on a concrete foundation. Piles were not required.

Between Water street and the Fitchburg railroad the gradient of the approach changes from 3 per cent. to $\frac{8}{10}$ of one per cent. This part of the structure is a solid earth fill, enclosed by granite walls similar in construction to the Water-street abutments. The wall towards the railroad, however, has a pile foundation.

South of the railroad a new passageway has been laid out, leading from Warren avenue to Charles-river avenue. The railroad and this new passageway are crossed by a bridge of two spans. The central pier is of granite masonry. The bridge is similar in construction to that over Water street, except that, owing to the limited depth available, asphalt is used for paving instead of granite blocks. The railroad, at this crossing, was depressed about 16 inches below its former grade. One of the elevated railway posts stands on the central pier. Its mate, owing to the skew of the bridge, stands in the sidewalk of the passageway, where it has a special foundation built in connection with the pier foundation.

The structure between the new passageway and the edge of the river consists of a one-story building with side walls and one end wall of granite ashlar backed with brick. The south end wall is the Charlestown abutment and parapet wall. Alternate brick cross walls and bents of steel columns divide the building into apartments about 25 feet in width, each provided with a large doorway at each end. It is believed that these rooms will be of value for storage. The walls rest on concrete foundations sustained by piles, except the south portion of the west side-wall, which rests on a granite dock-wall, built, like the Charlestown abutment, on

a concrete foundation resting directly on hard bottom, without piles.

The cross walls and columns support the roadway and sidewalks, which are also the roof of the building. This roof is made of steel beams supporting brick arches and concrete filling, upon which is laid a waterproofing coat and the granite block paving. The sidewalks are granolithic. The posts of the elevated railway stand on the brick cross walls before mentioned.

The east doors of the storage building open upon land acquired by the commission between the new structure and Charles-river avenue. The west doors open on a passageway 30 feet wide, connecting with the new passageway beside the Fitchburg railroad. The southern end of the 30-foot passageway is on piles in the river, and forms a wharf at which light-draft vessels can unload.

The construction of the Charlestown approach and the depression of the Fitchburg railroad necessitated changes in the grades and in the drainage scheme of Warren avenue, City square, Front, Water, Chelsea, and Chambers streets, and Charles river avenue. A number of new catch-basins were built, and several old ones were altered. Wherever the old paving was disturbed it was relaid temporarily on a gravel base. It was thought better not to use the more permanent and more costly concrete base until all settlement shall be surely at an end. For the same reason, wherever granite paving was laid over earth filling on either approach, a gravel base was used, and on the Boston approach and on the east side of the Charlestown approach north of Water street the sidewalks are of brick instead of granolithic.

*Removal of Charles River Bridge.*

After the new bridge was sufficiently advanced to be opened for travel the Charles River Bridge, in compliance with the terms of the license issued Dec. 27, 1895, by the War Department, was completely removed from harbor line to harbor line.

A list of the principal contractors accompanies this report.

Respectfully submitted,

WILLIAM JACKSON,

*Chief Engineer for Charlestown Bridge.*

## PRINCIPAL CONTRACTORS, CHARLESTOWN BRIDGE.

**PERKINS & WHITE,**

Ten Piers for River Spans.
Boston and Charlestown Abutments.
Fender for Pier 5.

**PERKINS, WHITE & CO.**

Draw Foundation and Fender Piers.

**WOODBURY & LEIGHTON,**

Retaining Walls, Boston Approach.
Superstructure of Warehouse Section, Charlestown Approach.

**DENNIS F. O'CONNELL,**

Charlestown Approach, including foundations for Warehouse section.
Water Street Pier.

**W. H. ELLIS,**

Extension of Draw Fender Pier, and removal of Charles River Bridge.

**A. & P. ROBERTS CO.**

Steel Work for Eight River Spans.
Steel Work for Water Street and Fitchburg R.R. Spans.

**THE PENNSYLVANIA STEEL CO.,**

Draw Span.
Steel Work for Two River Spans.

**MILLER & SHAW,**

Draw Machinery.

**GEORGE MCQUESTEN & CO.,**

Hard Pine Floor Plank.

**ROCKPORT GRANITE CO.,**

Granite Paving Blocks.

**DENNIS J. KILEY & CO.,**

Painting Steel-work, and laying Floor Plank, Waterproofing, and Paving.

**NORCROSS BROS.,**

Sub-flooring, and Erection of Steelwork, Water Street and Fitchburg R.R. Spans.

**SIMPSON BROS. CORPORATION,**

Asphalt and Granolithic Walks.
Asphalt Paving.

**JAMES RUSSELL BOILER WORKS CO.,**

Iron Railings.

**THE BUILDINGS CLEANING CO.,**

Painting Draw Span, Railings, and outer faces of Fixed Spans.

Painting and Whitewashing on Water Street and Fitchburg R.R. Spans, and in Warehouses.

**CAPE ANN GRANITE CO.,**

Cut-stone Balustrade, Charlestown Approach.

**P. O'RIORDAN,**

Filling of Boston Approach.

**JERE J. SULLIVAN,**

Filling of Charlestown Approach.

**JONES & MEEHAN,**

Paving and Regulating Streets adjacent to Boston Approach.

**SETH W. FULLER CO.,**

Electric Signal and Speaking Tube Systems.

**E. B. BADGER & SONS CO.,**

Copper-work on Draw Span.

**MALACHI SHIELDS,**

Drawtenders' House.

**WILLIAM J. LAWLER,**

Wharf for Warehouses.

# APPENDIX A.

CAUSTEN BROWNE AND ANOTHER *v.* ALFRED T. TURNER AND OTHERS.

SUFFOLK. Jan. 22, 1900. — March 28, 1900.

Present: HOLMES, C.J., MORTON, LATHROP, BARKER, and HAMMOND, JJ.

*Boston Subway — Construction of Tunnel to East Boston — Constitutional Law.*

Section 17 of St. 1897, c. 500, authorizing the construction of a tunnel from Boston to East Boston and the execution of a lease of the tunnel, when completed, to the Boston Elevated Railway Company, for twenty-five years from the date of that act, at the rental specified in the same section, and § 18 of the same statute, authorizing the city treasurer to issue bonds of the city to pay the cost of construction of the incline, etc., and other bonds to a certain amount, the proceeds thereof and of $7,000,000 in bonds authorized by St. 1894, c. 548, to be applied to the payment of the expenses of constructing, etc., the subways authorized by said St. 1894, c. 548, § 25, and the tunnels, etc. provided for in the preceding section, are not unconstitutional, as calling for an unwarranted exercise of the power of taxation, as taking the property of the city without reasonable compensation or due process of law when a lease as provided by statute, is executed to the Boston Elevated Railway Company, or as impairing the obligation of the contract already made by the Boston Transit Commissioners with the West End Street Railway.

HOLMES, C. J. This bill purports to be brought under St. 1898, c. 490, amending Pub. Sts., c. 27, § 129. As we are of opinion that it fails to make out a case, and as all parties are anxious for a decision upon the merits, we have not considered whether the plaintiffs bring themselves within the purview of the act. The decree will be the same that it would be if we were against them on the preliminary point, and therefore there seems to be no objection to stating the grounds of substantive law which seem to us to support the result.

The point of the bill may be stated in a few words. The Boston Transit Commission proposes to obey St. 1897, c. 500, § 17, by constructing a tunnel from a point on or near Hanover street in Boston proper to a point at or near Maverick square in East Boston, and by executing a lease of the tunnel, when completed, to the Boston Elevated Railway Company, for twenty-five years from the date of that act, at the rental specified in the same section. The treasurer of the city proposes to obey § 18 of the act by selling bonds and applying the proceeds to the payment of the cost of the tunnel. The plaintiffs seek an injunction on the ground that the requirements of these sections are unconstitutional, as calling for an unwarranted exercise of the power of taxation, as taking the property of the city without reasonable

compensation or due process of law when the lease is executed, and as impairing the obligation of a contract already made by the subway commissioners with the West End Street Railway.

In view of the decisions as to the subway, it does not appear to us to need further argument to show that the contemplated tunnel, even if permanently confined to street railway travel, is a public work for a public use, for building which the legislature can require the city to pay. Prince *v.* Crocker, 166 Mass. 347, 361. Mahoney *v.* Boston, 171 Mass. 427, 429. Local precedent is more important than abstract theory in determining this question, at least so far as the State Constitution is concerned; and if it be true, as it may be, that the difference between uses which are public within the requirements of the constitution and those which are not is one of degree, that is no novelty, and it is enough that this use has been determined to fall on the right side of the line. Apart from the distinctions suggested between the subway and the tunnel, which do not impress us, it is said that, because of the direction to let the tunnel, and because of the difference between the rental under the statute and that which would have been received under the contract which we have mentioned, the real object of the statute is to throw upon the city the burden of constructing part of its roadbed for a private corporation and to give it a lease on easier terms. We cannot accept the suggestion. It does not appear that the statute will have either effect. But if it will, so long as it is possible we are bound to assume that the legislature did its duty, meant what it said and regarded the work as a public work really needed by the public, as it may be. The purpose of the act on its face is to create a lawful public improvement.

The lease comes up in another aspect, however. It is said that the compensation to the city is inadequate, and that the lease will be a taking of the city's property for a private corporation without paying for it. Mt. Hope Cemetery *v.* Boston, 158 Mass. 509. With regard to the former proposition, if the legislature has the same power that it has with regard to other roads, the matter of compensation is wholly within its power. Norwich *v.* County Commissioners, 13 Pick. 60. Agawam *v.* Hampden, 130 Mass. 528, 530, 531, and cases elsewhere in this judgment. See also Mobile *v.* Kimball, 102 U.S. 691, 702; Williams *v.* Eggleston, 170 U.S. 304. Commonly, when a city or town is required to build a road or bridge within its limits no compensation is provided for beyond the local benefit of having it there. With regard to the latter branch of the objection, we are of opinion that the case is not like Mt. Hope Cemetery *v.* Boston, or that supposed of an act requiring a transfer of the city hall to a railroad company for a station. This is not a transfer, but only a temporary and quasi experimental lease for a not unreasonable time. The property of the city in the tunnel, assuming it to have a property, is not of a half private sort, as in case of the cemetery, but is merely the control of a public agency. There is no element of the Mt. Hope cemetery case about the matter. McHugh *v.* Boston, 173 Mass. 408. Commonwealth *v.* FitzGerald, 164 Mass 587, 589, 590. Kingman, petitioner, 153 Mass. 566, 574, 575. Cheshire *v.* Adams & Cheshire Reservoir Co. 119 Mass. 356. As was said at the argument, if the tunnel is to be built it is to be used, and naturally will not be used by the city directly. If the legislature could authorize it to be let on terms to be agreed upon, as was held in Prince *v.* Crocker, it could require it to be let upon terms which the legislature thought just, to a corporation selected by itself engaged in a public work like that for which the tunnel is to be used. In fact, when once the power to require the tunnel to be built is conceded, the rest follows, in the situation now existing in Boston. Assuming that the city is not to go into the transportation business further than it has gone, the use of the tunnel by the corporation which manages the consolidated street railways of the city is the alternative; and such use is not to be expected without a lease.

The contract the obligation of which it is said will be impaired is the former lease of the subway executed by the transit commissioners under Sts. 1893, c. 478; 1894, c. 548; 1895, c. 440; and 1896, c. 492. This lease was to the West End Street Railway Company, to whose rights the elevated railway company has succeeded, but was at a different rental from the present. The lease declares the word "subway" as used therein to include all the subways, tunnels, etc., which the commission has constructed or may construct under the aforesaid acts. As to future tunnels, of course this is not a lease but only a contract to let them if they are built under the said acts. The statute of 1894, c. 548, § 26, was to the effect that the commission "may construct a tunnel . . . from a point on or near Scollay Square in the city of Boston, . . . to a point on or near Maverick Square." Such a contract is not impaired in any way by a repeal of so much of the act as gives the commission authority to build, and it may be that, if it were necessary, we should say that a tunnel with a different terminus built in form under another and later act is not within the words of the lease, — that, in the words of Browne *v.* Turner, 174 Mass. 150, 160, the contemplated tunnel is "a substitute for the tunnel authorized by statute 1894." We prefer, however, to put our decision on more substantial grounds. The railroad company does not object to the change, as was the case in Walla Walla *v.* Walla Walla Water Co. 172 U. S. 1. The city has no greater interest in the lease than it has in the tunnel. Its interest in the lease is as much public property and as subject to legislative control as its interest in the tunnel. No part of the proceeds go to its private uses (St. 1894, c. 548, § 38; Mahoney *v.* Boston, 171 Mass. 427, 430,) and if any part did go to such uses it is hard to see how as against itself, the city by making a contract to let public property held by it subject to the control of the legislature could cut down this control. The control is not subject to the chance of the city's contracting, but the contract is subject to the power of the legislature over the subject matter. Essex Public Road Board *v.* Skinkle, 140 U. S. 334, 339, 340. New Orleans *v.* New Orleans Water Works Co. 142 U. S. 79, 91, 92. Chicago, Burlington & Quincy Railroad *v.* Nebraska, 170 U. S. 57, 72. Railroad Co. *v.* Ellerman, 105 U. S. 166. See Brighton *v.* Wilkinson, 2 Allen, 27; Brimmer *v.* Boston, 102 Mass. 19; Agawam *v.* Hampden, 130 Mass. 528, 530, 531 et seq. We assume, for purposes of discussion, without deciding, that the contract as to future tunnels was within the authority given by St. 1895, c. 440, § 6; St. 1896, c. 492.

Bill dismissed.

# APPENDIX B.

Canvass of Bids for Building Passageway under Tracks in Travers Street. Bids Opened Oct. 12, 1899.

| Bidders and Addresses. | 500 Cubic Yds. Earth Excav. | 2,400 Lin. Ft. Spruce Piles. | 190 Cu. Yds. of Concrete Masonry. | 18 Sq. Yds. Crude Paraffine to be Applied to Piles, etc. | 310 Sq. Yds. Tarred Felt, Pitch, etc. for Waterproof Coating. | 130 Sq. Yds. Plaster, Port. Cem. Mortar. | 3½ Tons Steel I Bms. Set in Place and Secured. | 64 Sq. Yds. Tar Concrete Pavement on Roof of Subway. | Time of Beginning. 1899. | Time of Completing. 1899. | Totals. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Charles G. Craib, 138 Pleasant street, Winthrop | $3 00<br>1,500 00 | $0 30<br>720 00 | $6 50<br>1,235 00 | $0 50<br>9 00 | $0 40<br>124 00 | $1 00<br>130 00 | $8 00<br>28 00 | $2 00<br>128 00 | Oct 19, | Nov. 30, | $3,874 00 |
| Metropolitan Contracting Co., 95 Milk street, Boston | 2 25<br>1,125 00 | 0 20<br>480 00 | 6 00<br>1,140 00 | 0 50<br>9 00 | 0 50<br>155 00 | 0 40<br>52 00 | 10 00<br>35 00 | 1 50<br>96 00 | Oct. 16, | Dec. 1, | 3,092 00 |
| G. M. Bacon, 194 Washington street, Boston | 1 97<br>985 00 | 0 27<br>648 00 | 5 39<br>1,024 10 | 0 40<br>7 20 | 0 35<br>108 50 | 0 35<br>45 50 | 6 00<br>21 00 | 2 50<br>160 00 | Oct. 16, | Dec. 1, | 2,999 30 |
| Guy C. Emerson, 170 Summer street, Boston | 2 35<br>1,175 00 | 0 25<br>600 00 | 4 25<br>807 50 | 0 30<br>5 40 | 0 30<br>93 00 | 0 20<br>26 00 | 6 00<br>21 00 | 1 25<br>80 00 | Oct. 18, | Dec. 6, | 2,807 90 |
| Gow & Foss, 8 Exchange place, Boston | 2 30<br>1,150 00 | 0 20<br>480 00 | 4 00<br>760 00 | 0 25<br>4 50 | 0 20<br>62 00 | 0 20<br>26 00 | 3 00<br>10 50 | 1 75<br>112 00 | Oct. 16, | Nov. 20, | 2,605 00 |
| Maximum | $3 00 | $0 30 | $6 50 | $0 50 | $0 50 | $1 00 | $10 00 | $2 50 | | | $3,874 00 |
| Minimum | 1 97 | 0 20 | 4 00 | 0 25 | 0 20 | 0 20 | 3 00 | 1 25 | | | 2,605 00 |
| Average | 2 37 | 0 24 | 5 23 | 0 39 | 0 35 | 0 43 | 6 60 | 1 80 | | | |

# APPENDIX C.

CANVASS OF BIDS FOR COVERINGS OVER ENTRANCES TO PASSAGEWAY UNDER TRACKS AT TRAVERS STREET, OCT. 26, 1899.

| BIDDERS AND ADDRESSES. | Amount. |
|---|---|
| Norcross Bros., Boston, Mass. | $2,500 00 |
| E. B. Badger & Sons, Boston, Mass. | 2,150 00 |
| S. D. Hicks & Son, Boston, Mass. | 1,800 00 |

# APPENDIX D.

CANVASS OF BIDS FOR ARTIFICIAL STONE-WORK IN PASSAGEWAY UNDER TRACKS AT TRAVERS STREET, DEC. 22, 1899.

| Bidders and Addresses. | Amount. |
|---|---|
| M. J. Fitzgerald, 164 Devonshire street, Boston | $922 50 |
| Simpson Bros. Corp., 166 Devonshire street, Boston | 570 72 |
| Aberthaw Const. Co., 7 Exchange place, Boston | 434 00 |
| W. A. Murtfeldt Co., 192 Devonshire street, Boston | 323 00 |

# APPENDIX E.

CANVASS OF BIDS, SECTION A, EAST BOSTON TUNNEL, APRIL 20, 1900.

| Bidders and Addresses. | 18,000 Cu. Yds. Earth Excavation. *a* | 50 Tons Iron and Steel set in place and secured. *d* | 10 Cu. Yds. Concrete Masonry Rosendale Cement Mortar. *f* | 6,000 Cu. Yds. Concrete Masonry Portland Cement Mortar *ff* | 60 Cu. Yds. Stone Masonry for Sidewalls of Incline and Portal of Tunnel. *h* | 34 Cu. Yds. Coping Stone Masonry. *i* | 3,000 Sq. Yds. Plastering of Portland Cement Mortar. *q* | 2,300 Sq. Yds. Waterproof Coating Asphalt or Similar Substance. *t* | 17,500 Sq. Yds. Tarred Felt, Pitch, etc. *tt* | Totals. |
|---|---|---|---|---|---|---|---|---|---|---|
| Jones & Meehan, Boston, Mass... | $1 75<br>31,500 00 | $15 00<br>750 00 | $8 00<br>80 00 | $9 50<br>57,000 00 | $25 00<br>1,500 00 | $40 00<br>1,360 00 | $0 40<br>1,200 00 | $0 35<br>805 00 | $0 20<br>3,500 00 | $97,695 00 |
| W. H. Keyes & Co., Boston, Mass. | 1 53<br>27,540 00 | 10 60<br>530 00 | 6 90<br>69 00 | 9 20<br>55,200 00 | 22 00<br>1,320 00 | 27 00<br>918 00 | 0 50<br>1,500 00 | 0 40<br>920 00 | 0 40<br>7,000 00 | 94,997 00 |
| C. H. Eglee Co., Boston, Mass.... | 1 87<br>33,660 00 | 5 00<br>250 00 | 6 50<br>65 00 | 8 25<br>49,500 00 | 25 00<br>1,500 00 | 16 00<br>544 00 | 0 30<br>900 00 | 0 25<br>575 00 | 0 05<br>875 00 | 87,869 00 |
| United Engineering & Contracting Co., New York............... | 1 25<br>22,500 00 | 12 00<br>600 00 | 7 00<br>70 00 | 9 00<br>54,000 00 | 30 00<br>1,800 00 | 45 00<br>1,530 00 | 0 25<br>750 00 | 0 23<br>529 00 | 0 15<br>2,625 00 | 84,404 00 |
| H. A. Hanscom & Co., Boston, Mass...................... | 0 90<br>16,200 00 | 15 00<br>750 00 | 8 00<br>80 00 | 9 50<br>57,000 00 | 28 00<br>1,680 00 | 38 00<br>1,292 00 | 0 50<br>1,500 00 | 0 40<br>920 00 | 0 25<br>4,375 00 | 83,797 00 |
| National Contracting Co., New York........................ | 1 35<br>24,300 00 | 15 00<br>750 00 | 5 65<br>56 50 | 7 35<br>44,100 00 | 29 50<br>1,770 00 | 50 00<br>1,700 00 | 0 50<br>1,500 00 | 0 45<br>1,035 00 | 0 15<br>2,625 00 | 77,836 50 |

# APPENDIX F.

## CANVASS OF BIDS, SECTION B, EAST BOSTON TUNNEL, JUNE 14, 1900.

| BIDDERS AND ADDRESSES. | 79,000 Cu. Yds. Earth Excavation. (Bet. Sta. 8 + 19 & 43 + 15.) | 23,000 Cu. Yds. Earth Excavation. (Sta. 43 + 15. to Wly. end of Sec.) | 1,000 Tons Iron and Steel, set in place and Secured. | 100 Tons Iron and Steel Tie-rods, set in place and secured. | 250 Tons Iron Segmental Castings, set in place, etc. | (Bet. Sta. 8 + 19 & Sta. 43 + 15.) 29,000 Cu. Yds. Concrete Masonry, Port. Cem. Mortar. | (Sta. 43 + 15 to Wly. end of Sect.) 9,000 Cu. Yds. Concrete Masonry, Port. Cem. Mortar. | 34,000 Sq. Yds. Coating, Hydraulic Cement Mortar. | 2,000 Lin. Ft. Spruce Piles. | 12,000 Sq. Yds. Waterproof Coating. | 5,700 Sq. Yds. Tarred Felt, Pitch, etc. | Days from July 1, 1900, to Date of Completion. | Totals. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *a* | *2 a* | *d* | *2 d* | *e* | *ff* | *2 ff* | *g* | *s* | *t* | *tt* | | |
| United Eng'r'g & Cont. Co., New York City...... | $11.00<br>869,000 | $8.00<br>184,000 | $20.00<br>20,000 | $30.00<br>3,000 | $20.00<br>5,000 | $24.00<br>696,000 | $17.50<br>157,500 | $0.75<br>25,500 | $0.40<br>800 | $0.75<br>9,000 | $0.50<br>2,850 | 974<br>Mar. 1, 1903 | $1,972,650 |
| National Cont. Co., New York City.. | 12.00<br>948,000 | 8.00<br>184,000 | 30.00<br>30,000 | 50.00<br>5,000 | 50.00<br>12,500 | 17.00<br>493,000 | 13.00<br>117,000 | 0.75<br>25,500 | 0.50<br>1,000 | 1.00<br>12,000 | 0.50<br>2,850 | 716<br>June 15, 1902 | 1,830,850 |
| Jones & Mechan, Boston, Mass... | 12.00<br>948,000 | 10.00<br>230,000 | 20 00<br>20,000 | 25.00<br>2,500 | 30.00<br>7,500 | 15.00<br>435,000 | 15.00<br>135,000 | 0.60<br>20,400 | 1.00<br>2,000 | 1.00<br>12,000 | 1.00<br>5,700 | 458<br>Oct. 1, 1901 | 1,818,100 |
| W. J. Gawne & Co., Cleveland, O.... | 5.75<br>454,250 | 6.50<br>149,500 | 20.00<br>20,000 | 40.00<br>4,000 | 30.00<br>7,500 | 11.40<br>330,600 | 12.75<br>114,750 | 0.35<br>11,900 | 0.40<br>800 | 0.40<br>4,800 | 0.25<br>1,425 | 1,096<br>July 1, 1903 | 1,099,525 |
| Shailer & Schniglau Co., Chicago, Ill. | 5.25<br>414,750 | 5.00<br>115,000 | 15.00<br>15,000 | 15.00<br>1,500 | 20.00<br>5,000 | 10 00<br>290,000 | 10.00<br>90,000 | 0.30<br>10,200 | 1.00<br>2,000 | 0.40<br>4,800 | 0.20<br>1,140 | 1,080<br>June 15, 1903 | 949,390 |